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TWELFTH REPORT

OF THE

STATE ENTOMOLOGIST

OF

MINNESOTA

TO THE GOVERNOR

FOR THE YEARS 1907 AND 1908.

SIXTH REPORT OF F. L. WASHBURN.

AGRICULTURAL EXPERIMENT STATION.
ST. ANTHONY PARK, MINN.
DECEMBER, 1908.

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LETTER OF TRANSMITTAL.

STATE EXPERIMENT STATION,
ST. ANTHONY PARK, MINN.,
December 1st, 1908.

To His Excellency, John A. Johnson, St. Paul, Minn.

DEAR SIR: The State Entomologist has the honor to present herewith his biennial report of the years 1907 and 1908. As will be remembered by you, it was suggested for the sake of economy, and to better present the work of this division, that a printed report from the Entomologist should be issued only once in two years, not annually as heretofore, and that from time to time as occasion demanded, press bulletins or press notices, circulars, or station bulletins, should be issued to meet the wants of the farmers, horticulturists and others, the law being complied with by filing with you annually on or before December 1st, a typewritten abstract of work accomplished, and an account in detail of all expenditures incurred in discharge of the work. This plan met with your approval, and appears to give excellent results, besides effecting a saving in this department of several hundred dollars annually. The bringing to the notice of farmers and others important information regarding insects at just the time when it is needed, by means of press notices, circulars and press bulletins, is better than waiting for the publication of a report.

General Insect Conditions: The years 1907 and 1908 have been average years as regards insect depredations, though in some instances certain species of insect pests have been prominently in view. The occurrence of the "Green Bug," so-called, created a great flurry here a year ago this summer, and the Entomologist did everything possible to get the exact facts before grain growers, and to allay a scare which was, in a large measure, artificial.

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In the springs of 1907 and 1908, Black Flies, small two-winged insects belonging to the family *Simulidae,* frequently called Buffalo Gnats or Turkey Gnats, were much complained of. Milch cows fell off in milk; stock of all kinds in pastures located in affected regions and at work in the field, were driven wild; in certain instances young poultry was killed, and farmers and others lost in consequence. By means of press articles, and by mailing to parties concerned, from this office, a pamphlet on "Insects and Insect-like Animals Affecting Stock," it is to be hoped that some measure of relief was afforded.

Our 1907 mail brought in many inquiries regarding plant lice, for the most part on grain, said inquiries being largely occasioned by the alarming rumors of the presence of the "Green Bug." In almost every instance, when specimens of these grain lice were sent to this office, they proved to be a native form, *Macrosiphum granaria,* present with us in varying numbers each year, and causing little or no damage.

The Hessian Fly worked upon grain in 1907 and 1908, showing, as was to be expected, some increase in the depredations in the latter year.

Native grasshoppers, noticeably the common Red-legged Locust or Grasshopper, the Two-striped Locust, and the Lesser Migratory were abundantly present in some portions of the state in 1907, causing some injury to grain and clover. Last year complaints reached us from Kanabec, Otter Tail, Isanti, Wright and Itasca counties. This year, 1908, they have been still more numerous. Accounts of their depredations have increased. They have, the present season, worked in Otter Tail, Norman, Chisago, Sherburne, Wadena, Anoka, Meeker and Stearns counties, affecting principally clover and alfalfa and pasture lands. The outlook for next year, unless farmers take certain measures, is not particularly reassuring, since our native forms, when very abundant, can be exceedingly destructive. Press Bulletin 32, containing an account of preventive treatment, was issued in September. A copy of this will be mailed to any farmer upon request. In this connection it is interesting to note that grasshoppers by consuming pastures may materially affect the price of milk.

Wire worms, controlled largely by proper farm practice, have been destructive in certain localities, one farmer known to us, feeling obliged to disk his corn and sow flax, since the former plants had been destroyed by these pests. Just across the line in North Dakota wire worms were reported as having destroyed, in one locality, one hundred acres of grain.

This office has been appealed to in both 1907 and 1908 for suggestions leading to relief from the presence of ants in household and garden. Lawns have been injured and in some places ruined by the White Grub. The irritating Harvest Mite, *Leptus irritans,* although nearly invisible to the naked eye, has, tiny as it is, placed a ban on picnic parties, ladies and children particularly being subject to attack. Frequently the work of this tiny mite is thought to be "rash" or "hives." Red blotches appear on the skin, accompanied by an almost unbearable itching, which lasts for several days.

The Apple Leaf Hopper, *Empoasca mali,* has been active in nurseries, possibly not so bad in 1908 as in 1907, and has, at the request of the U. S. Department of Agriculture at Washington, been made the subject of special work by the Entomologist under the Adams Fund. Various other apple tree insects have been in evidence, and numerous complaints of the Plum Leaf Gall Mite have been received.

Shade trees have suffered materially in different localities from a number of pests. Elms have been affected with lice which are peculiar to that tree. Some oak trees were devastated, notably in Otter Tail and Wadena counties, by the Oak-leaf Caterpillar. The Stalk Borer (different species of *Papaipema*) has again injured flower gardens.

The Fall Web Worm has been locally destructive and on the increase. Press Bulletin 28, issued from this office in November, 1907, deals with this pest. In 1908 oak trees suffered from the Oak Tree Pruner. Box elder and maples have been attacked by a Maple Twig Borer, reared to the moth stage in the insectary, which may prove to be a new species. Young ash trees in at least one nursery have been destroyed by the hundreds through the work of one of the Stalk Borers, *Papaipema furcata,* this caterpillar boring in the soft center; and large ash trees in one locality have been riddled by a boring Sesiid, *Aegeria fraxina,* tunneling in the solid wood. As we go to press, also, cuttings from birches which have been killed through the work of the Birch Borer, *Agrilus anxius,* have been left at the office. The Poplar Beetle, *Lina scripta,* has been in evidence, eating the leaves of these trees. A borer in locusts, *Cyllene robiniae,* has also been very troublesome.

In connection with shade tree pests we have been frequently consulted by the forester of the Minneapolis City Park Board, Mr. C. N. Ruedlinger, and have extended to him, and through him the Park Board, all the assistance possible.

Grapes have, as usual, suffered from the attacks of various insects, the fruit being attacked by a Grape Fruit Worm, and the leaves by the Grape Vine Flea Beetle, *Haltica chalybea,* and the Grape Phyllox-

era, *Phylloxera vastatrix,* specimens of the latter being sent us from both wild and cultivated vines at Albert Lea. This latter pest has been present with us on wild vines for some time, and in the event of its becoming abundant on cultivated plants, may call for strenuous action on the part of the grape grower. It is a form of louse which works on both roots and leaves of grape vines, and has called for special legislation in some countries.

The Codling Moth and Plum Curculio have, as usual, been busy on apples and plums, as well as two or three species of plant lice, and we list a small beetle known as *Scirtes tibialis,* looking like a flea beetle, seriously injuring the leaves of plums, its first reported occurrence in Minnesota.

Crown Gall: This infectious plant disease, attacking raspberries and blackberries, particularly the former, was noticed by us here in abundance for the first time in 1907, though it has been known to occur here before. Its source has been traced to a few nurseries apparently, where owners have promised us to stamp it out as far as they can. The disease is of such a serious nature, and so destructive to raspberries that a special illustrated publication was issued regarding it. From a legal standpoint a nurseryman is not entitled to a certificate from the State Entomologist as long as this disease is found upon his stock.

One strawberry grower has reported (1908) the presence of the Strawberry Root Louse, *Aphis forbesi,* in his fields. As this is the first time its occurrence here has been known to us, this department is keeping in touch with the case, and making it an object of special study.

Special Experiments: The Office of Experiment Stations at Washington has suggested the life history of the Apple Leaf Hopper and of the Grain Plant Louse, *Macrosiphum granaria,* as special problems for this division of the Experiment Station. To these it has added *Bruchophagus funebris,* an insect which seriously affects the production of clover seed. The life histories of these three pests have never been completely worked out, and during 1907 and 1908 the entomological force has made special effort in this direction. Most gratifying results have been obtained from work with the first of these, *Empoasca mali,* and progress made with the other two.

Work with the "Green Bug" has been continued, both in field and insectary, and this louse is found to be quite generally distributed over the state, but by no means in dangerous numbers. It has been

discovered that eggs passed successfully through last winter here, and hatched in the spring. A number of other grain plant lice have also been exhaustively studied.

Work with the Cabbage Maggot has been continued during 1907 and 1908, our attention in the latter year being principally given to treatment of radishes to prevent its attack. In the summer of 1907 one man devoted almost his entire time to the studying of means of protecting cabbage and cauliflower plants from the attacks of this pest. Results of this work, embodied in advice and suggestions, were mailed to all market gardeners in April, 1908, as Circular No. 9 from this office, "Remedies for the Cabbage Maggot." Several parasites new to science have been reared from this pest.

Plum Curculio: In 1907 and 1908 experiments were carried on by Mr. Ruggles, an assistant in this department, to test the value of spraying plum trees with arsenate of lead, and have proved conclusively that a large per cent of fruit can be saved by spraying at the proper time with this compound.

Comparisons of Liquid Spray and Dust Spray: During the two years just past these two widely different agents have been tested upon the Russian orchard at the Experiment Station, which orchard was courteously placed at our disposal by the Horticultural Division. This work was directed against the Apple Scab, the Plum Curculio and the Codling Moth. The results largely favor the liquid spray as being more advantageously used than the dust spray.

Hydrocyanic Acid Gas: Experiments with this dangerous but effective medium, made by combining cyanide of potash with sulphuric acid, have been continued, to get further data as to the time elapsing between the dropping of the charge into the acid, and the giving off of the gas; also the distance into a mass of meal or bran to which this gas can penetrate effectively.

Office Publications: In addition to various communications to the state press, from time to time as occasion demanded, the following publications have been issued from this office during 1907 and 1908:

1907 "Three New Hymenopterous Parasites of *Pegomyia brassicae*" (technical).

Nov., 1907 Press Bulletin 28, "1. The Fall Web Worm a Menace in Minnesota. 2. Autumn Remedies for the Stalk Borer in Flower Gardens."

Feb., 1908 Experiment Station Bulletin No. 105, "The Importance of the Study of Entomology; How to Collect and Preserve Insects."

Feb., 1908 Circular No. 6, "Crown Gall in Minnesota."

Feb., 1908 Circular No. 7, "Mediterranean Flour Moth."

Mar., 1908 Special Report to the Governor, "The So-Called 'Green Bug' and Other Grain Aphids in Minnesota in 1907."

April, 1908 Experiment Station Bulletin No. 108, "The So-Called 'Green Bug' and Other Grain Aphids in Minnesota."

April, 1908 Circular No. 8, Press Bulletin No. 31, "Suggestions to Those Contemplating Spraying."

April, 1908 Circular No. 9, "Remedies for the Cabbage Maggot."

May, 1908 "A Comparative Study of the External Anatomy of Plant Lice," by R. A. Vickery, Assistant (technical).

Sept., 1908 Circular No. 10, Press Bulletin No. 32, "Insects Affecting Grain and Allied Crops During 1907 and 1908."

Oct., 1908 Circular No. 12, "Destruction of Lawns by the White Grub."

Nov., 1908 Circular No. 13, Press Bulletin 33, "Some Destructive Shade Tree Pests.

Nov., 1908 Circular No. 14, Press Bulletin 34, "Spraying for the Plum Curculio."

Lectures: The following lectures upon insects and kindred subjects, illustrated in most instances with stereopticon, were given in the months and at the places named: April, 1907, Lake City; December, 1907, Pelican Rapids; January, 1908, Hope Chapel, Minneapolis; February, 1908, Twin Valley; July, 1908, Spicer (Chautauqua series); November, 1908, Crookston; November, 1908, Meadowlands.

Correspondence: The Entomologist's mail has been increasing each year. Its character is, to a certain extent, indicated by the insects listed under "General Insect Conditions," for there were numerous inquiries in connection with these. In 1907 there were approximately 1,500 letters, and in 1908, 1,767 letters. The bulk of this correspondence occurred between June 1st and September 15th of each year, the period when insects are most active, and consequently when the heaviest demands are made upon the Entomologist.

Nursery Inspection: In 1907 fifty-four nurseries were inspected, and certificates granted their owners. In 1908 this number was increased to fifty-nine. As a rule we find Minnesota nurseries well cared for and free from serious pests. A careful watch, however, will be kept for Crown Gall.

Insectary: The insectary is proving especially valuable in our work. We have reared several parasites, some of them new to science, and from various pests, notably the Cabbage Maggot, and have also been enabled to make careful study of life histories of grain insects and other injurious pests, and to so work upon these in the dead of winter as to really double the quantity of work which was done before the building was erected. In 1907 four hundred and sixty separate experiments were carried on in the insectary, and in 1908 to date, four hundred and fourteen. Experiments now running embrace such sub-

jects as the Bee Moth, Clothes Moth, Confused Flour Beetle, various plant lice, notably those affecting grain; the Wheat Stem Maggot, the genus of Stalk Borer known as Papaipema (we have already found that several species occur here), the Oak Pruner, Maple Borer, Elm Borer, Birch Borer, Apple Leaf Hopper, *Bruchophagus funebris* and other insects affecting clover, etc. We regard the insectary as not only a very valuable, but an actually necessary adjunct to the work.

Acknowledgments: In conclusion, it gives us pleasure to acknowledge our appreciation of the favorable conditions attending our work during the past two years. We have been fortunate in the matter of assistants. In addition to Mr. A. G. Ruggles, permanent assistant, to whom the department is indebted for originating and installing, during the past two years, numerous valuable filing devices, we have had during the summer of 1907 Mr. R. L. Webster and Mr. George G. Ainslie, both close observers and useful workers in field and insectary. Mr. R. A. Vickery served in the insectary from October, 1907, and during the earlier part of the summer of 1908 was working almost constantly in the field under our direction. These three men have recently accepted government positions in the Bureau of Entomology. In July, 1908, we were fortunate enough to secure the services of Dr. H. J. Franklin, a graduate of Amherst, and a skilled expert in insectary work. He came to us with the best of recommendations, and his work since he has been here substantiates the favorable report which preceded him.

The Director and the different divisions of the Experiment Station have been particularly kind in granting favors which facilitated the work of the Entomologist. Our state press has been a means, always generously at our disposal, when it has been necessary to bring information regarding an insect pest quickly to the notice of farmers and other citizens.

Our thanks are especially due various specialists at Washington and elsewhere for naming for us species belonging to their several groups.

Finally, we wish to acknowledge the kindly interest in the progress of the work shown by the Governor of the State during the past two years.

Respectfully,
F. L. WASHBURN,
State Entomologist.

FINANCIAL STATEMENT FOR FISCAL YEAR, AUGUST 1, 1907, TO AUGUST 1, 1908.

Apiary	$19.56	
Assistant Entomologist	674.97	
Cuts, etchings and drawings for illustrating reports and bulletins	700.65	
Experimental garden	9.99	
Express	112.50	
Freight	11.34	
Insectary assistant	277.35	
Insectary building materials	67.49	
Insecticides	32.36	
Labor	127.53	
Laboratory supplies	131.42	
Lantern slides and slide boxes	21.85	
Models of injurious insects	175.00	
Office shelving, cases, etc	164.45	
Office assistants	107.70	
Office supplies and apparatus	113.02	
Optical goods	76.69	
Photo material and apparatus	162.95	
Plates for report and bulletins	473.25	
Postage for correspondence and reports	100.00	
Printing	477.25	
Publications, clippings and library	47.82	
Spraying apparatus and tools	31.10	
Stationery, etc.	68.50	
Stenographer and clerk	480.00	
Telegrams	8.66	
Telephone	56.80	
Traveling expenses of State Entomologist	101.52	
Traveling expenses Assistant Entomologist	97.81	
		$4,929.1
Credit, sale of one gas machine		150.(
		$4,779.1

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APPLE LEAF HOPPER.

THE APPLE LEAF HOPPER AND OTHER INJURIOUS INSECTS OF 1907 AND 1908.

BY F. L. WASHBURN

TWO YEARS' WORK WITH THE APPLE LEAF HOPPER, *Empoasca mali* LeB.

Synonyms: *Empoa albopicta* Forbes, *Tettigonia mali* LeB., *E. albopicta* Woodworth, *Typhlocyba photophila* Berg.

Explanation of colored plate: Figs. 1, 2, 3, 4 and 5 represent five successive stages of the nymph; Fig. 6, the adult Leaf Hopper; Fig. 7, the newly hatched nymph (summer) issuing from petiole of clover. The central figure illustrates the appearance of the terminal portion of an apple twig upon which this Leaf Hopper is working.

SUMMARY OF RESULTS.

1. This insect is at least two-brooded in Minnesota, young nymphs appearing upon apple trees soon after the leaves open, and the last brood of adults ovipositing in the tissues of the bark of apple (and other?) trees. The eggs of the summer broods are laid in the petiole of clover, apple, and doubtless many other plants, which furnish them food during the summer months.

2. There are five nymphal stages, and the length of time elapsing between hatching of egg and appearance of adult averages about twenty-two days. The adult may live fourteen days or over. Experiments of 1907 indicate that thirty days or more may be passed in adult stage.

3. The presence of the winter egg is denoted by a blister-like swelling on bark of apple, about .75 mm. long by .4 mm. broad. The contained egg is about as long as the blister, hyaline and semi-opaque. See Fig. 5.

4. **This insect occurs upon a large number of plants other than the apple; among them may be mentioned plum, maple, bur-oak, black oak, thorn apple, basswood, hazel, box elder (very abundant), choke cherry, sumac, European birch, cut-leaf birch, syringa, snowball, raspberry, blackberry, bush beans, corn, clover, alfalfa, sugar beets, buckwheat, dahlia, hemp, rhubarb, potatoes, different grasses, etc.**

5. **It does not work serious injury to orchard trees, but retards the growth of nursery stock, obliging the nurseryman to market his trees, if affected, when four years old, instead of three.**

6. **From 1908 observations it would appear to be desirable to plant nursery stock at a distance from apple orchards.**

7. **The best results as regards remedial measures were obtained by the use of shields or screens smeared with tangle-foot. This is effective only against the adults, and might well be used against adults of the first brood.**

8. **Sprays containing kerosene are not desirable.**

9. **Fish oil soap, 1 lb. in 10 gals. of water, kills adults and young if they are not too well concealed in the curled leaves.**

This leaf hopper, extremely common in Minnesota, belongs to the Hemipterous family *Jassidae*, and has been known in this country since the early 50's, when it was described (1853) by LeBaron under the name of *Tettigonia mali*. The insect does not have a complete metamorphosis, but hatches from an egg laid in the petiole, leaf or bark of various plants into a form called a nymph, which resembles the adult very closely. See Fig. 6 of Colored Plate.

Fig. 1. Second stage of *E. mali*, from life, much enlarged. Original.

When first hatched the nymphs are almost colorless, but after they have taken nourishment they become a pale orange or greenish yellow. After hatching from the winter eggs they crawl up and settle on the under sides of the young apple leaves. They are active creatures and move rapidly when disturbed. The young hoppers, with the exception of those in the last nymphal stage, always walk. According to observations made at this Station by R. L. Webster in 1907, individuals in the last nymphal stage may either walk or hop. Hoppers in that stage were distinctly seen in several instances, to leap a

distance of over a foot, when slightly disturbed. The adult hoppers fly as well as hop, as may be readily seen by shaking an infested nursery tree, causing the tiny insects to leave it, often in clouds.

The average length of individual nymphs of the first stage is .8 mm.; of the second, 1.3 mm.; of the third, 1.7 mm.; of the fourth, 2.1 mm.; of the fifth, 2.4 mm.; and of the adult, 3.1 mm.

The length of life of each nymphal stage, as found by Dr. Frankling in insectary work in 1908, is as follows: First stage, three to five days; second stage, one day; third stage, six days; fourth stage, six days; fifth stage, four days, or an average of twenty-two days from egg to adult. These data are the results of one experiment only. The 1908 observations are corroborated, as far as the total time is concerned, by the work of 1907, when it was found that the insect spent from nineteen to twenty-five days in the nymphal stages, though Mr. Webster did not, in 1907, determine the length of time spent in each stage. The adult may live at least fourteen days, and probably longer, according to insectary observations in 1908. The 1907 insectary experiments indicate that the adult may live more than twice that length of time.

Fig. 2. Third stage of *E. mali*, from life, much enlarged. Original.

The Winter Egg: The winter egg, we believe, is laid during the latter part of September in the bark of apple (and other?) trees, its presence being denoted by a blister-like raising of the outer portion of the bark, under which it may be found. Fig. 5 is made from a photograph of an egg, after it had been exposed by careful dissection by Dr. Franklin, and Fig. 6 shows a nymph hatched from such an egg. We have been unable to find fall laid eggs in any herbaceous plants, though during the summer many varieties of such growths are swarming with *Empoasca*. The egg blisters measure from .7 mm. to .85 mm.

Fig. 3. Fourth or pupal stage of *E. mali*, from life, much enlarged. Original.

The egg pockets from which our measurements were made (and which we believe to be those of *E. mali*, because of their resemblance to those on nursery stock from which *E. mali* was reared) were

Fig. 4. Egg blisters of *E. mali*, much enlarged. Original.

first found in abundance September 23rd upon the smaller branches of apple trees in an orchard eight years old, located next to an alfalfa field, which was very heavily infested with *E. mali* during the summer. Each pocket or blister contained a single egg, apparently fresh. At that date the hoppers were less abundant in this alfalfa field than they had been, and had been growing markedly less throughout the latter half of September. This field was swept with a collecting net as late as November 4th, and at no time was *E. mali* found in abundance, only a few specimens being taken at a sweeping. This is to be regarded as evidence that it does not winter in the adult or any other but the egg stage, since none were found November 4th.

Fig. 5. Egg of *E. mali*, dissected from blister, much enlarged. Original.

The above mentioned blisters, containing fall laid eggs, were found throughout the orchard referred to, but were apparently most numerous on the side adjoining the alfalfa field. They were most plentiful on the second and third year's growth from the present, according to Dr. Franklin's report, though he found them occasionally on the growth next to the present year's growth and they were often found to be rather numerous on the fifth year's growth from the present. Only one egg blister which appeared to be that of *E. mali* was found on last season's growth.

On November 18 a considerable amount of three-year-old nursery stock was carefully examined and measured and the winter egg blisters found upon it. It was impossible to distinguish these blisters from those found on the apple trees in the orchard by the alfalfa field, previously described in detail. On this nursery stock, however, these blisters were considerably more numerous on next to the present year's

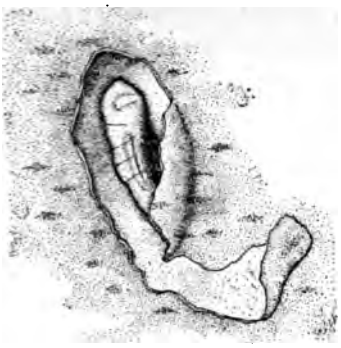


Fig. 6. Nymph of *E. mali* within its pouch or blister, much enlarged. Original.

growth than was the case on the trees in the orchard. This growth was as large (in diameter) on this nursery stock, however, as the second year's growth from the present was on the trees in the orchard.

It should be noted here that Mr. Webster (Jour. Econ. Ent. Vol. I, No. 5, p. 326) says that the winter egg pockets of *E. mali* which he found "on three-year-old apple stock" were "in the bark on the lower portion of the trees, below the first branches." This location of the egg blisters described by Mr. Webster is for young nursery trees of three years' growth, precisely the same position as described above for larger trees, for on three-year-old nursery stock "the lower portion of the trees below the first branches" would be the second year's growth from the present. The positions of the egg blisters, then, in both cases have the same relation to the age of the growth of the bark within which they were deposited. Distance from the ground does not appear to have the influence on the location of the egg-blisters of this species which one might naturally expect. To be sure, these blisters seem to be somewhat more abundant on the lower branches, but the upper branches also have a considerable supply. Branches at different heights were also examined, and these blisters were found as high as seventeen feet and three inches from the ground. Two branches over twenty feet high were examined, but no blisters were found at that height. Only rarely were these blisters found on large limbs and trunk, though other blisters, similar in appearance, but somewhat larger, were common on these portions.

It seems probable that the adults of *E. mali* choose, for fall egg-laying, the particular portions of the tree where the blisters are found to be most numerous, because those portions bear bark which is best suited to protect the eggs and is, at the same time, tender enough to make oviposition easy. The newest growth is not chosen, apparently, either because its bark is not dense enough to afford satisfactory protection from winter weather, or because its more rapid growth might crush the eggs. It is quite probable that the old bark on the main limbs, and on the trunks of the trees is too tough for easy oviposition.

The egg blisters themselves are usually very slightly crescentric in form, though often simply elongate-oval, and at one end of each there is an inconspicuous short, slanting incision or opening, where the ovipositor was passed into the bark at the time of oviposition.

The egg inside of these blisters is not imbedded in the bark as deeply as are those of other species, the blisters of which are found commonly on apple trees. They are covered by the epidermis and the corky portion of the bark, and only a thin layer of cortical parenchyma. The eggs of the other species have a thicker layer of cortical parenchyma between them and the corky portion of the outer bark.

The eggs themselves are of about the same length as the pockets which cover them, but they measure somewhat less than .2 mm. in greatest width. They are elongate and nearly circular in cross section, slightly curved from end to end, of about equal width throughout their length, and rounded at their ends. They have very delicate, transparent shells, and it is difficult to open one of the blisters so as to expose one without crushing or puncturing it. One of these eggs may be most easily uncovered for examination by first cutting into the bark with a fine scalpel, on both sides of the egg blister, and then joining these two cuts at some little distance beyond that end of the blister which shows the incision of the ovipositor. The covering of the bark may then be lifted up from the egg, beginning at the place where the two cuts are joined, with a pair of tweezers.

The end of the egg which is nearest to the opening made by the ovipositor always protrudes slightly through the cortical parenchyma covering, and is cemented to the under surface of the overlying corky layer. The cortical parenchyma layer will often rupture very easily and allow the egg to be pulled away readily with the corky layer. Fig. 5 shows one of these eggs pulled out in this way, and still adhering to the corky layer.

These eggs, when first examined, were filled with clear, semi-transparent liquid material, which was broken up considerably into small globules. When examined, November 2nd, many of them were still in this condition, but many were slightly clouded in spots on the inside, and in some the young nymph, though still very small and shapeless, could be seen to have already taken form. These nymphs were at that time white in color, and they occupied but a very small part of the interior of the egg. They could be seen to move slightly now and then. Dr. Franklin examined carefully and measured certain egg-blisters on the small branches of elm trees, which were similarly located with re-

Fig. 7. Field beans, on left hand, normal; those on right injured by *E. mali*.

spect to the new growth of the elm, to what the apparent egg-blisters of *E. mali* are on the apple. He was able to discover no difference between these elm blisters and the apple blisters. Their measurements were the same, and they were the same in general appearance. A number of these elm blisters were opened and the eggs which they contained were like those in the apple blisters. These blisters on the elm were much less numerous than those on the apple branches. It seems probable that these elm blisters are blisters of *E. mali*, or of some closely allied form. The fact that the elm and the apple are not closely related plants, argues, of course, against this view, but it is quite possible that the character of the bark which a tree bears on its small branches may have more to do with this matter than does the relationship of the species. Franklin examined a considerable number of other kinds of trees and shrubs, but found no blisters on any of them which resembled these, which appear to be those of *E. mali*, though egg-blisters of other species were found in abundance. These, however, could be easily distinguished by their size, shape, depth in the bark, and general appearance. Among the trees and shrubs thus examined for these blisters were plum, poplar (two species), willow (two species), sugar maple, soft maple, mountain ash, white birch, hackberry, boxelder, elderberry, gooseberry, currant, oak, cherry, hawthorne, cornus, lilac, spruce, pine (white), and cedar.

The Summer Egg: Nymphs found emerging from petiole of clover, Fig. 7 colored plate, and from petiole of apple, indicate two places of oviposition during the summer season. From the large variety of food plants upon which it is found abundantly in summer, it would seem as though it must oviposit upon a great variety of growths.

We sectioned clover leaf petioles in August in looking for the eggs. We found the inner tissue broken, and appearing as though the egg had been placed longitudinally in about the center of the petiole. After the emergence of the nymph the hole which affords it exit closes, and leaves only a narrow horizontal slit, barely noticeable. Dahlias examined September 30th had adults and nymphs upon stem and petiole. Minute slit-like scars were also found on these plants. In this connection it is interesting to note Mr. Ainslie's observations in 1907, which tally with those made this year.

"On the petioles of a very few of the leaves (apple) something appeared to be the matter. This took the form of a small, discolored pore on the petiole of the leaf. In one or two this pore was open, but in the others it was closed and was evident from a slight discolora-

tion of the bark around it. The pore, when open, was elliptical, and always had its long axis parallel with the petiole. The opening was a scant .5 mm. long. The bark was slightly raised in the neighborhood, and of a darker shade as if diseased. The whole thing was barely visible to the naked eye. The enlargement was very slight, and in most of those seen, was on the side of the petiole, neither above nor below, and usually on the half nearest the blade of the leaf. I found a single one which was very small and seemingly imperfect, about half way out the blade on the under side of the midrib. Upon dissection I was not able to make out anything definitely, but thought I saw traces of some foreign body in the plant tissue. I examined several buckwheat plants rather thoroughly, and found a couple of similar looking places on the petioles."

Number of Broods: There are surely two broods of *Empoasca mali* during the season in Minnesota, and almost certainly three. It is easy to define the first two broods, which are fairly well separated. Allowing forty days for each cycle, which seems a fair estimate from the data we have at hand, and bearing in mind that they first appear about May 25th (1907), or soon after the leaves open, we would have, in round numbers, one hundred and twenty days, to September 25th (at about which time adults grew appreciably less in numbers), permitting of three such cycles.

Field Observations in 1907: The first appearance of the young leaf hoppers was on May 25th, when Webster found newly hatched nymphs on leaves of three-year-old apple stock in a nursery at Albert Lea. A thorough search May 20th at this place failed to reveal any of the nymphs, but they were found fairly numerous at this latter date. The leaves of apple stock were less than two inches long at this time, the average length being one inch. It would be safe to say that the young hatch about two weeks after the buds burst. Only one specimen was then found on the two-year-old stock, the majority appearing on the older stock.

First brood of adult hoppers were first seen outside at Owatonna on June 19th, on apple, elm, maple and boxelder. At this date young hoppers were also found, but only on the apple. Specimens of adults were taken on European birch, cut-leaf birch and plum on June 20th at Owatonna, but no nymphs were found on these trees. On July 1st, young (of the second brood possibly) were very common at Owatonna, the majority of nymphs being in the second nymphal stage. On July 14th, at Albert Lea, Webster found hoppers very numerous, those in the last nymphal stage by far the most common. All stages were

represented, however, and from this time on until the end of the season no definite observations were obtained in regard to the number of broods.

On July 16th young *Empoasca* were found feeding on quack grass, *Agropyron repens* at Albert Lea, and also on the same grass at Faribault August 30th. Young hoppers were found very late in the season. On September 3rd newly hatched nymphs were found on apple stock on yearling as well as three and four year stock in a nursery at Faribault, and they were found at a still later date (Sept. 19) at Albert Lea.

Fig. 8. Alfalfa, on right, normal; on left injured by *E. mali*.

Field Observations in 1908: May 6th, Albert Lea: No young hoppers on leaves of apple.

A prominent nursery man made the following comment during this visit at Albert Lea: The leaf hopper retards the growth of nursery stock, and, if it were not for the hoppers, apple trees could be marketed at three years instead of four. The trade requires a tree between five and six feet high.

May 28th: St. Anthony Park: Found in all stages upon apple.

June 1st, Owatonna: *Empoasca* present in all stages in apple orchard and on apple stock in nursery. But few adults.

June 18th, St. Anthony Park: Leaf hoppers present in all stages on boxelder, but most numerous in first and second stages, indicating probably that the second brood had just hatched. No eggs found at this date; they are probably laid by the aduts of the first brood inside the tissues of the new and tender growth.

June 26th, Monticello: Hoppers present on boxelder in first, second and third larval stages. Second stage rather numerous on boxelder. Not found on choke cherry, wild plum nor hazel.

June 28th, St. Anthony Park: In third, fourth and fifth stages on apple. Not found on plum.

June 29th, Red Wing: Adults and all nymphal stages present on elm and boxelder, many being in first stage.

July 6th, Albert Lea: Apple stock that will be three years old this fall examined, and also one-year-old stock. Leaf hoppers found to be more numerous in sheltered places.

July 6th: Nymphs on choke cherry, sumac, bur-oak, thorn-apple, and maple. Not found on hazel, though search was made for them.

July 18th, St. Anthony Park: Adults rather numerous on the under side of the leaves of corn.

July 20th: Nymphs of all stages, and adults very plentiful on sweet clover, which was in bloom on this date. Adults very numerous on new leaves of black oak. One adult found on hazel, and both young and adults on blackberry.

July 22nd: All stages present on sugar beets in small numbers. All stages abundant on beans; all stages found on basswood. Many adults and all stages of young on boxelder. All of these adults were probably adults of the second generation, and undoubtedly there are three or more generation in a season.

July 23rd: Adults on syringa, snowball, carragana. Adults and young on *Physocarpus opulifolius*. Adults and young in all stages on blackberry; a few adults on raspberries.

July 24th, Olivia: Adults on corn in small numbers. No nymphs.

July 26th, Ortonville: Searched for on ash, elm and sumac without success. Adults and young present in small numbers on boxelder.

July 29th, Hallock: Abundant in all stages, boxelder leaves badly curled.

August 12th: Adults abundant and nymphs scarce on raspberry; present in all stages on blackberry, also on rhubarb, hemp, potato, sugar beets, and very abundant on beans and alfalfa. As a result of

their attack on the two latter plants, the leaves curled badly, and many turned white.

In order to kill the large proportion of the first brood, before eggs are laid for the second, it would seem to be advisable to collect them with some form of hopper dozer, sticky shields for instance, every day for about a week, at the time when they first appear.

From work with contact sprays at this time, it does not seem at all desirable to use kerosene emulsion. We are becoming more and more convinced that kerosene in any form is not a safe agent for the general public to use against insects.

It might be a desirable thing, in view of the fact that leaf hoppers are found on old orchard trees, to grow nursery stock, wherever possible, at some distance from apple orchards, so that the nursery stock may not have to endure heavy annual infestation from these old trees. In other words, from our observations in the past two years, it seems probable that the leaf hopper, when it occurs upon anunal growths in the open fields, is entirely killed out by the cold weather in the winter, and that each year's infestation starts from trees or shrubbery possibly, mainly from apple trees. Hence, it is possible that young apple stock, if isolated from other trees, would not suffer as much as if close to orchards, and it is further probable that if such nursery stock is sprayed with Bordeaux mixture between the middle and latter part of August, the spray will act as more or less of a repellant, and help to keep the hopper away.

SPRAYING EXPERIMENTS AGAINST LEAF HOPPERS.

Experimental work against the apple leaf hopper in 1907 was carried on at Albert Lea and at Owatonna. The greater part of the work was done at Albert Lea, since the leaf hopper was more abundant at that place than at Owatonna. A Wallace Junior Power sprayer was used in both of these nurseries, the one at Owatonna having been purchased by this department especially for the purpose of carrying on experimental spraying. The machine at Albert Lea was the property of a commercial nursery at that place. Both sprayers were built with a two and one-half foot track, enabling the whole machine to pass between the rows of the apple stock to be sprayed. In the machine at Albert Lea the nozzles were placed along two arched rods in the rear of the machine, thus allowing the spray to be thrown on both sides of the two rows at the same time. Owing to the fact that older and higher trees were sprayed at Owatonna, the use of the arched rods was impractical. Only straight rods were used on these higher

trees, necessitating driving the machine in every row. On account of the varying width of the rows, and the irregular growth of the trees of some varieties, a few trees were scraped by the machine, more particularly in the older stock at Owatonna than in the three-year-old stock at the other nursery. Fine Vermorel nozzles were used on both machines, and the spray thrown as much as possible from below, so as to strike the under sides of the leaves.

Kerosene emulsion in different proportions, fish oil soap, tobacco water and resin wash were the different sprays used in the experimental work. At Owatonna kerosene emulsion only was used. The other sprays were applied at Albert Lea.

Kerosene Emulsion: Kerosene emulsion was made after the following formula: 2 gals. of kerosene, 1 gal. of water, and 12 oz. of Lenox soap. This stock solution was diluted to different proportions. A 5% solution was sprayed upon apple stock at the Wedge nursery June 14th, but this strength was found far too weak to be effective, only about 10% of the total number of young hoppers being killed by it. On June 17th and 18th a 7½% solution of emulsion was used. In one case 55% and in another 75% of the nymphs on the trees were killed.

A 10% solution of emulsion was used at Albert Lea on the same date, resulting in killing 46% in one case and 61% in another. A 10% solution of kerosene emulsion was also used at Owatonna with success. Two sprayings were made, the first June 19th, and the second July 18th. The counts which were made at Owatonna showed a higher percentage in the number of nymphs killed than at Albert Lea for the same strength of solution, but so few trees were counted in the Owatonna experiment that the data are not sufficient to base a very definite percentage upon. Very many of the nymphs were in the older stages at this time, and very active, so that counts would be subject to considerable error.

Fish Oil Soap: Fish oil soap was used at Albert Lea on July 17th at the rate of 1 lb. of soap to 10 gals. of water. The soap was first boiled in a large kettle, adding water to assist in dissolving. The heavy soap solution was then poured into a large spray pump, and water added so as to make the proper proportion of 1 lb. soap to 10 gals. water. At this time the leaves at the top of the trees were badly curled by the leaf hopper, and the fine spray could not penetrate those curled leaves so as to kill the hoppers within. A large number of nymphs escaped injury on account of being hidden in these curled leaves. Where fairly hit with this spray both adults and nymphs were

killed. The sides and top of the Wallace sprayer were covered with dead hoppers, the greater proportion of which were adults, and but few nymphs. The soap solution gave, as near as could be determined, practically the same benefit as the 10% kerosene emulsion solution.

Tobacco-soap Solution: Twelve pounds of tobacco stems were steeped in 12 gals. of water for an hour and a half, and five bars (60 oz.) of Lenox soap were added. The soap was allowed to dissolve, and enough water added to make fifty gals. of the solution. This was applied to the apple stock with the Wallace Power sprayer. The same difficulty was experienced in this case as in the case of the fish oil soap, namely that of hitting the hoppers in the curled leaves. Where hit young hoppers were killed, but the spray had little or no effect upon the adults. Compared with fish oil soap, and the kerosene emulsion spray, the tobacco soap solution was considerably less effective than either of the other two.

Resin Wash: This wash was made as follows: Eight lbs. of resin and 6 lbs. of common washing soap were boiled in two gals. of water for nearly two hours. After boiling, the mixture was diluted to about 10 gals. It was then poured into the sprayer tank, and 70 gals. more water were added, thus making the proportion of 1 gal. of the stock solution to 7 gals. of water.

An attempt was made to spray this solution upon apple stock with the Wallace Power sprayer. The resin, however, adhered to the sides of the pump cylinder, forcing the plunger to work with great difficulty, and giving insufficient pressure with which to spray. Finally the attempt to spray with this mixture had to be abandoned. On those trees where it was applied the resin wash covered the leaves thoroughly, with the exception of the curled leaves in the tops of the trees. The wash was effective when touching nymphs on uncurled leaves. As far as could be determined, there was no effect upon adult hoppers.

STICKY SHIELDS.

These have been used in New York and elsewhere against the Grape Leaf Hopper, and a trial was made with them at Owatonna in 1907.

A light frame was made 3 by 4 feet with a handle, and covered with heavy cloth; the cloth was then covered with O. & W. Thum's Tree Tanglefoot, a one-pound jar making a heavy coating to within two inches of the edges of the frame. This grade of tanglefoot is

rather stiff in consistency, and a thinner grade could have been used and covered more surface. One man held the frame by the handles, walking down one side of the row of trees, while the other jarred the trees from the other side. A gentle breeze was blowing at nearly right angles with the rows, and the shield was used on the side facing the wind. The hoppers left the trees in swarms when jarred, and flew with the wind and downward, the greater part of them being caught by the tanglefoot on the sticky shield. On account of the fact

Fig. 9. Sticky shield in use in nursery.

that the hoppers flew downward, more were caught on the lower side of the frame than on the other. Two men, in working for ten minutes, covered two hundred and ninety feet in a row of five-year-old apple stock, and an actual count of the number of leaf hoppers on the frame caught in ten minutes' work was 3,221, on a surface 3 by 4 feet. About 95% of these were adults.

This experiment was made at Owatonna the 19th day of July, when most of the hoppers on the trees were adults. Doubtless such a time would be the best to make use of the sticky shields, but a

month earlier would have caught the adults of the first brood. If used at a time when the first brood hoppers are on the trees, or at any time, in fact, when the winged hoppers are most numerous, it seems that the shields can be practicable. The work is slow, and necessitates careful treatment, but is certainly effective.

WORK WITH A HOPPERDOZER.

In July, 1908, alfalfa on experimental plots at the Station was being badly injured by leaf hoppers of this species. The insects were in all stages, and were so numerous upon these plants that they flew

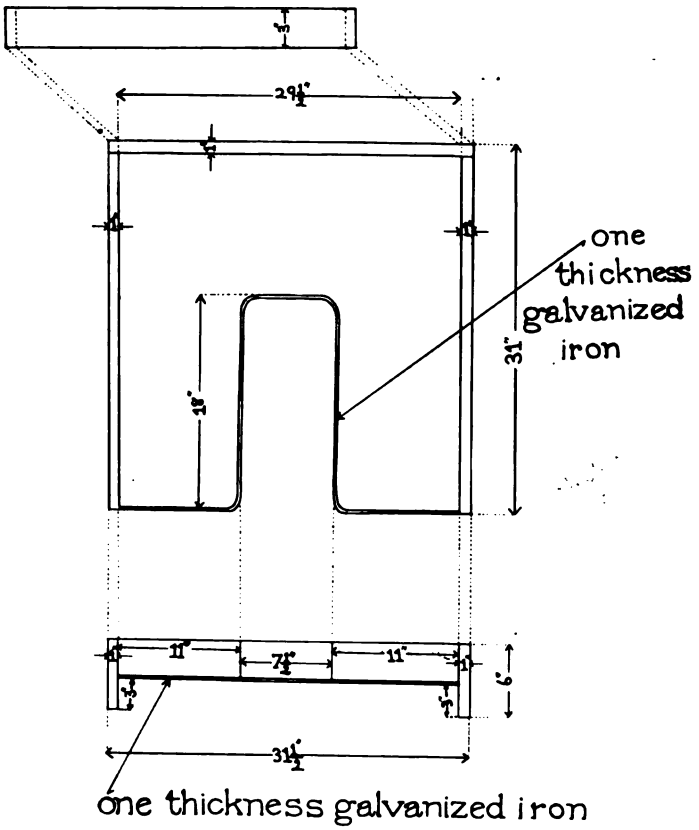


Fig. 10. Diagram of pan of hopperdozer used in 1908.

up in clouds when the plants were disturbed. Previously, and not under the direction of this Division, these plants had been sprayed with kerosene emulsion, with disastrous results as far as the plants were concerned. About August 11th a hopperdozer was made from

the plans below, particularly to save this alfalfa, but since the idea appears to be a good one, and one which will suggest something similar or better, not only for experiment station work on trial plots, but on a commercial scale, where low growing plants, which grow in rows, are affected, we go into some detail regarding its construction, and illustrate fully the method of its use. As a result of employing it once, fully fifty per cent of the hoppers on these plots were killed.

The hopper dozer above referred to was made of two parts, the lower of these parts consisting of a U-shaped pan and of one thick-

Fig. 11. Pan.

ness of galvanized iron. The edges of this pan were two inches high. A one-inch board, five inches wide, was nailed on to each side of the pan to serve as a runner, and a similar board two inches wide was nailed to the back. The tops of these boards were all even with the edge of the pan all the way around. A stout cord was attached to the front end of each runner with which to draw the apparatus.

The upper portion (see Figs. 12 and 13) of the hopper dozer was made up of a frame work consisting of four two-foot corner posts, held together by pieces nailed on top, and similar pieces nailed on the sides and ends about three inches from the bottom. This frame was covered with canvas.

This upper portion of the hopperdozer was so constructed that the lower ends of the corner posts of the frame set down snugly into the corners of the pan, and the pieces which were nailed around the sides of the lower part of the frame fitted closely against the upper edge of the pan, thus forming a closed box when the upper and lower portions of the hopper were put together, except that the canvas on the

Fig. 12 Frame of hopperdozer.

front side of the upper portion did not reach clear across, but gapped in the middle to allow for the passage of plants through the hopper. This hopper was designed by Mr. R. A. Vickery primarily for use against *Empoasca mali* on experimental rows of alfalfa, but there seems to be no reason why it could not be used for bush beans as well, or for any other kind of low plant grown in rows, which may become seriously infested with *Empoasca*, or any other similar leaf hopper,

It has proved to be a fairly successful form of hopper dozer in the experiments in which it was used on the alfalfa.

Fig. 13. Front view of hopperdozer.

Fig. 14. Dozer ready for use on alfalfa plots.

Before being used, crude petroleum was put into the pan, and the canvas covering of the upper portion was also soaked with it. It was then dragged along over the plants in the rows, the plants all passing in at the middle of the front side of the hopper, and into the U-shaped recess in the front of the pan, against the inner end of which they struck with some force, jarring the insects off into the petroleum in the pan.

It seems probable, from our experience, that this hopper dozer might be improved by reducing the abruptness of the corner where the galvanized iron is turned up at the inner end of the U-shaped recess, thus making the hopperdozer less liable to break over or injure plants.

GRASSHOPPERS.

During the season just closing very many complaints of grasshopper ravages have reached us. They have been injurious in Otter Tail County (always a grasshopper county when the insects are in special evidence) about Fergus Falls, Perham and other towns; near Hendrum, near Lindstrom, about Wadena, at Clear Lake, Litchfield, St. Cloud, Oak Grove, Swan Lake, Zimmerman and North Branch, representing, in addition to Otter Tail, the counties of Norman, Chisago, Sherburne, Wadena, Anoka, Meeker and Stearns. These, so far as seen, were native forms, but some varieties of native forms may be exceedingly destructive when present in large numbers, as they have been this year. The Rocky Mountain Locust or grasshopper was not reported. The species sent to us for examination and identification were the Red-legged Locust, the Two-striped Locust, the Pellucid Locust and the Lesser Migratory Locust, the latter being a close cousin to the Rocky Mountain form, and doing considerable injury a few years ago both in Otter Tail County and in the northwestern part of the state. The clover crops of A. Byson, J. W. Miller, John Plantenberg, Anton Lubesmeier, near St. Cloud, and the same crop on the ground of William Weyrauch, Stephen Hinkemeier and Joseph Hinkemeier, of Clearwater; Alphonse Fisher, John Mauer, Peter Puetz, Jos. Braun, of Sauk Rapids, and Fred Meyer, of South Haven, were partially or entirely lost. In other localities it was either clover, alfalfa or pasture land which suffered.

On August 18th, 1908, Mr. Ruggles was sent to St. Cloud in response to complaints received from that place, and visited W. S. and Roy McConnell. It had been reported that grasshoppers were eating and destroying fields of clover which were being saved for seed. In company with Mr. W. S. McConnell he drove around the country for three hours, and many farms southwest of St. Cloud were visited. The hoppers were extremely abundant, and in many cases the heads of clover had been eaten off entirely, so that absolutely no seed was left. From what they said it would appear that several hundred acres were destroyed in this manner. About two weeks previous to this date Mr. McConnell had used the Criddle Mixture, and on this date one could find many dead bodies

of the insects. Evidently, however, the Criddle Mixture had not been used early enough, for hundreds of live hoppers were seen to every one dead. The principal species seen were *Melanopus femur-rubrum* and *M. bivitattus*.

A few reports have reached us of their depredations on grain this season, and all Minnesotans know what ruin they can work upon wheat and other cereals when they are present in large numbers. In order to prevent a possible injurious attack upon our grains next year, we take this opportunity to urge upon farmers visited by them this year to take certain measures to protect their next year's crop.

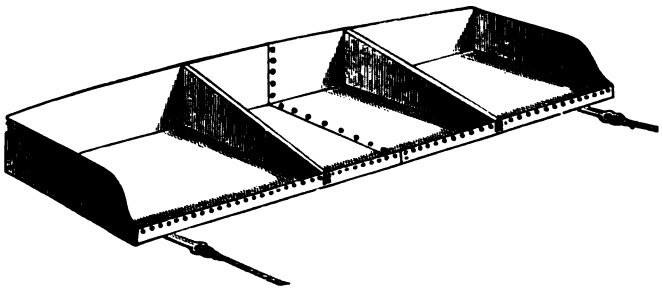


Fig. 15. Hopperdozer for grasshoppers with partitions. After Riley.

Preventing Hatching by Fall Plowing: Grasshoppers lay their eggs in the surface of the soil (stubble, pastures, fields, roadsides, etc.) to a depth of about one inch. Their eggs are laid in a pocket made by the female, and the young hoppers, upon hatching, climb up to the surface and into the open air. It has been found that he always instinctively crawls up, even though the pocket be turned upside down, and manifestly if he crawls up when the pocket is upside down, he reaches the end of the pocket, cannot get out, and dies. Plowing turns the pockets upside down, and if co-operation among neighboring farmers is practiced, is the best method available for controlling the grasshopper situation. This plowing should not take place until all egg-laying is finished, and is preferably done in the fall, though it might be done, when necessary, in the early spring, not later than May 10th or 15th, for grasshoppers are apt to issue in normal years in May or early in June. Further, the plowing of land in tillage is not alone sufficient, if eggs are known to exist in dangerous numbers elsewhere. Any land known to harbor eggs in quantity is a menace until it is plowed. Manifestly, for one man to plow while his neighbor leaves untouched egg-infested land on his side of the fence, is labor wasted, and for evident reasons.

To Save a Valuable Crop When Hoppers Are First Hatching: Let us suppose that a farmer who has a fine stand of grain, or other crops, notes during the early summer that very small hoppers, just hatched, are appearing in enormous numbers in a pasture adjoining, or near his wheat field. He is alarmed, and reasonably so, for the safety of his near-by crop. The method of procedure in this case is to plow the dangerous field where the hoppers are hatching, beginning at the extreme edge and working toward the center. This buries many of the pests, and, by turning the grass under, starves nearly or quite all of the others before they are able to reach the edge of the treated field.

Placing a strip of plowed land between a crop and an advancing army of quite young hoppers will sometimes turn their march and prevent loss. Sowing a strip of rye around the edge of a wheat field is claimed to be a simple way to keep grasshoppers at the edge of the field. The rye grows more rapidly than the wheat, and will stand much "eating down." This keeps the locusts in a comparatively narrow area where they can be easily handled. It may be said here that the method of letting the land lie fallow encourages the grasshopper evil.

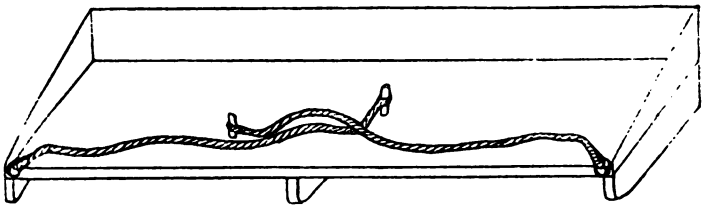


Fig. 16. Hopperdozer for grasshoppers with three runners.

The accompanying cuts illustrate very well the structure and method of using hopperdozers. They are made of sheet iron or galvanized iron. The front edge of the horizontal portion is turned up about two inches. The corners are riveted. Upon the rear is attached vertically a light wooden frame, which is later covered with canvas. An ordinary sized hopperdozer is about eight feet long, and before the above mentioned wooden frame is attached resembles a shallow pan. Runners (about three to a dozer), turned up slightly in front, are crudely made of pieces of sapling or board. The front ends of these are fastened to a crosspiece, to each end of which rope is attached. These ropes in front are fastened to a single-tree. The pan may or may not be divided into compartments, the latter preventing in a measure the swashing about and loss of the liquid, and are particularly desirable on uneven ground.

Fig. 17. Two hopperdozers tied together.

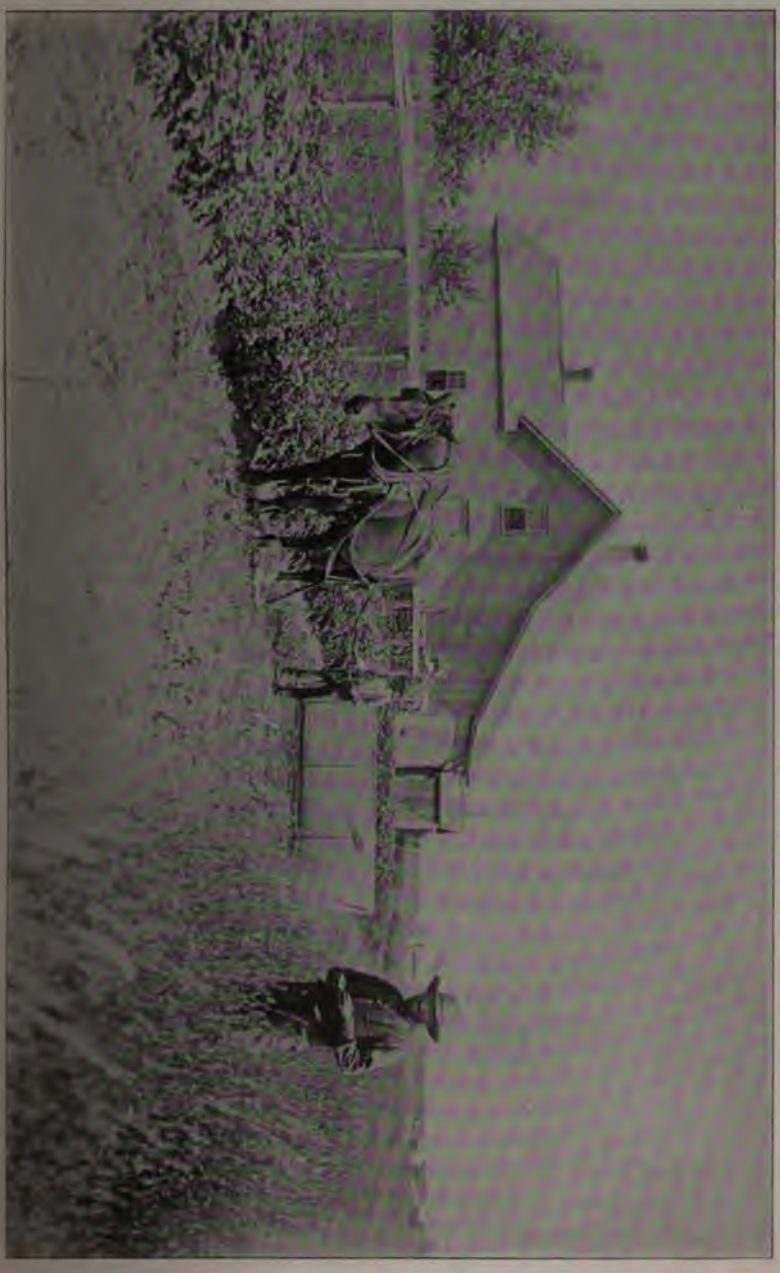


Fig. 18.—Single hopperdozer in use.

When wanted for use, a little water is placed in pan, and thrown against the canvas covered frame. The latter is then drenched with kerosene, and about a quart or less is poured on the water in the pan. The farmer then drives this back and forth over fields of young grain which is being eaten, and many of the hoppers jump either against the canvas back, or directly into the pan. Many jump out

Fig. 19. Common Red-legged locust or grasshopper, *M. femur rubrum*. After Riley.

again, but only to die later, as one slight touch of kerosene is all that is needed to kill the insect. Wherever the ground is level and free from stones, it is possible to join two, three or four hopperdozers together by means of ropes, thus making a very long pan. Do not use too much kerosene, and avoid spilling it, since it is destructive to plant life. The work is best done when the day is bright and warm.

Hopperdozers, however, are but a makeshift. They are of little or no value when the hoppers are fully winged. Sometimes many bushels of these young pests are destroyed in this way and a crop is saved, but in view of the labor and time involved in this process, we look upon fall plowing of infested land as the best remedy. Fall plowing is far better than plowing in the spring, since it allows the rain and snow to compact the ground, insuring the death of the confined insects.

The state has provided an emergency fund to be used by the State Entomologist in fighting grasshoppers, from which, when necessary, in a bad grasshopper year, he can furnish kerosene oil in limited quantities to farmers who own hopperdozers. The method to be followed

Fig. 20. Lessor migratory locust or grasshopper, *M. atlanis*.

in securing the oil is as follows: First procure a hopperdozer, then obtain from your county commissioner an order for oil upon some dealer in your neighborhood. Orders in blank form may be issued from this office to the commissioners. Upon presentation of this order at the store, oil will be furnished you, the dealer keeping your

receipt and the order to serve as a voucher when he sends his bill to the entomologist. **All bills for oil must be presented before December 1st of the year in which the oil is sold. Firms furnishing oil free to farmers without a signed order from a county commissioner do so at their own risk.**

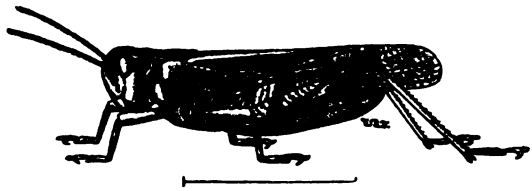


Fig. 21. Pellucid locust or grasshopper, *Camnula pellucida*.

Killing by Poisons: Grasshoppers are susceptible to Paris green, and when timothy fields or pastures are infested with eggs, and the farmer feels that he cannot plow such land, he may, when it is possible, poison a strip of plants about ten feet wide, growing on the edge of the grain field, and fenced away from stock, with arsenate of lead or Paris green. Stock in an inclosed pasture will gradually drive the hoppers to the poisoned plants outside.

Garden truck to which chickens do not have access may be protected to some extent by mixing bran with water to the consistency of chicken food, mixing with it Paris green until the mass has a decided green color (about two pounds of Paris green to twenty-five pounds of bran) and sweetening with cheap molasses or syrup. Balls of this stuff can be strewed amongst the plants we wish to protect, not allowing them, however, to come in direct contact with the plants.

Fig. 22. Two-striped locust or grasshopper, *M. bivittatus*. After Riley.

The best poison, however, and the cheapest, is known as **The Criddle Mixture;** this has proved an excellent remedy in Canada and elsewhere, provided it is used while the hoppers are small and

hungry. Our personal observations at the Station would seem to indicate that the full grown insects are not attracted. It is made by mixing 1 part Paris green, 2 parts salt, and 100 parts fresh horse manure by measure. Add enough water to make soft without being sloppy. It can be taken to the field in a tub on wagon or stoneboat, and scattered about by means of a paddle. It is most effective when fresh, but, it is claimed, will do excellent work when several weeks old. This does not appear to endanger the lives of turkeys or other full grown fowl. It might be dangerous if used in proximity to small chickens.

GRASSHOPPER LAW.

The following is taken from the Revised Laws of Minnesota, 1905, pp. 449 et seq.:

"Sec. 4. Grasshopper infection—Hearing and notice. Whenever written complaint is made to a county board that any tract of land in the county is so infested with grasshopper eggs as to threaten the destruction of grasses or crops in the vicinity thereof, the board shall fix a time and place for a hearing thereon, and cause notice of such hearing to be served upon the owner or person in charge of such infested land at least ten days prior thereto.

"Sec. 5. Same—Order to plow. Upon the hearing, which may be adjourned from time to time by the board, the certificate of the entomologist, stating that he has examined the tract involved, and giving the result of such examination, shall be prima facie evidence of the facts therein stated. The board shall hear all evidence offered by interested parties, and if, in its opinion, the tract is so infested, it shall make an order, giving the date of the hearing, the substance of the complaint, and the decision of the board thereon and directing the owner or person in charge to plow any designated part or all of said land before a date therein prescribed. The date shall be so fixed as to allow a reasonable time for such plowing after service of the order.

"Sec. 6. Same—Service of order. The auditor shall immediately cause the order to be served upon the owner or occupant of the land therein described. If the land be unoccupied, and the owner be a non-resident of the county, service may be made upon any person

having charge of such land and residing in the county. If the owner be a non-resident of the state, or his residence be unknown, and he have no known agent in the county, two weeks' published notice of such order shall be given.

"Sec. 7. Same—Failure to obey. If the order be not complied with, the board shall cause the infested land to be plowed at the expense of the county. In case such plowing shall be of value in the raising of a crop during the season immediately following, the person so benefited shall be liable to the county for such value. When the board is of the opinion that such liability exists, it shall determine the amount thereof, and its determination shall be prima facie evidence of such value. It shall direct the auditor to demand payment of the amount, and, if it be not paid upon demand, the county attorney shall bring a civil action therefor in the name of the county."

In concluding these remarks upon grasshoppers, it may be said: There is no question but that plowing, particularly fall plowing, is the best, cheapest and mose effective means in the hands of the farmer

Fig. 23. Rocky Mountain locust or grasshopper, *M. spretus*. After Riley.

for combating grasshoppers, yet farmers who are not planning to plow for crop purposes are not always ready to go to this trouble and expense until they see some actual damage done by these pests; a statement from an entomologist that certain stubble fields are riddled with grasshopper eggs does not always influence the owner to take prompt action, and the eggs are allowed to lie unmolested. It is not until these hatch, and the young hoppers becoming quarter or half grown seek to appease a ravenous appetite by inroads upon the growing grain, that the hitherto indifferent farmer realizes the fact that something must be done immediately to prevent the loss of from fifty to a hundred per cent of his crops.

Even then it is not too late, if the farmer takes immediate action, to overcome this small but powerful enemy to agriculture. He may, if the hoppers are not too large to get out of the way of the plow, say a half an inch or less, plow the infested land, working from its edge toward the center. This turns most of the pests under, causing their death.

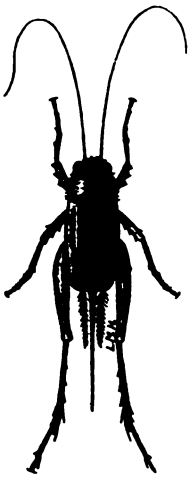


Fig. 24. Striped ground cricket, *Nemobius fasciatus var. vittatus.*

If the farmer prefers, or if the grasshoppers have become too large to treat in this way, the hopperdozer, so fully described above, may be made use of, or recourse may be had to a poisoned bait, the so-called Criddle Mixture, which is herein described.

It is interesting to note that at this date (Sept. 18, 1908) the state press is quoting the entomologist as predicting a "grasshopper plague" next year. This is somewhat of an exaggeration, for there are no indications at date of writing to promise that, yet it has been our experience here in Minnesota that when our native forms, especially the Lesser Migratory Locust, *M. atlanis*, get very abundant, they cause locally great loss, and it is to prevent this that we are sounding the above warning. Should we ever be so unfortunate as to have a visitation from the Rocky Mountain Locust, such as we experienced in the '70s, they would, the first year, probably come upon us in enormous winged swarms, attacking and devouring everything green, and calling for most strenuous work on the part of the farmer, aided by state help. Should this devouring host deposit eggs here, as it doubtless would, the methods of protection for the farmer to follow are as outlined above.

In this connection the following clipping from the October 1st issue of Wheelock's Weekly (Fergus Falls) is significant:

"Marine, Minn., Sept. 23.—A small shower of grasshoppers passed over on the afternoon of the 17th; some alighted. It caused some of the people to repeat some of their old-time grasshopper experiences, which to some sounded a little fishy, but nevertheless are quite true."

The following letter from Prof. Jensen is interesting, recording, as it does, a beneficial characteristic of one of our common crickets:

Eagle Bend, Minn., Sept. 23, 1908.

Dear Sir:—

While engaged in entomological studies a little north of Eagle Bend I noticed a female Striped Ground Cricket, Nemobius fasciatus form vittatus, very busy digging a hole on a bare spot. I watched it for some time and meanwhile found two other females near by engaged in the same occupation. After about ten minutes one of them had reached something that it began to eat, biting out piece after piece and finally pulling out what proved to be the remainder of a locust egg. The cricket held this and kept on eating from it until I caught it.

The other two were observed with the same result, the depth to which each one had to dig to reach the first eggs of the egg-masses being about one-fourth of an inch. A male was later seen feeding on an egg-mass that apparently had been denuded by a heavy shower the preceding night. By microscopically examining these eggs and also eggs taken from a female Melanoplus vittatus, I found that they were identical, and concluded that if the crickets take such pains to obtain the eggs of this species of Melanoplus they may possibly also destroy those of other species of the genus, as, for instance, femur-rubrum. The Ground Crickets are here in Todd County almost as numerous as the locusts, and it seems that possibly one pest may effectively help to hold another in check.

I have not been able to find any record of a like observation in the orthopteran literature that I have. In case you should wish to correspond further with me with regard to this, I shall be very glad to do so if you will kindly address me at Cornell University, Forest Home, Ithaca, N. Y.

Respectfully yours,

J. P. JENSEN.

Crickets have long been known to be omnivorous, but this is the first recorded instance, to the best of our knowledge, of his working a direct benefit to the farmer by consuming the eggs of locusts. By all means let the good work go on, and encourage *Nemobius* in every possible way—if he does not eat binder twine. Unfortunately this cricket, as well as others, does not restrict itself to a carnivorous diet, but sometimes is quite injurious to grain.

LICE AFFECTING GRAIN IN 1907 AND 1908 WITH NOTES ON INSECTARY WORK.

THE SPRING GRAIN APHIS, OR THE SO-CALLED "GREEN BUG."

Toxoptera graminum Rond.

The year 1907 was made memorable by the "Green Bug Scare," founded on a substantial basis in the South and a few of the southwestern states, but entirely uncalled for in Minnesota, where, though the species was found well distributed over the state, it did no damage. Nevertheless so great was the excitement caused by exaggerated, and, in some instances, manufactured reports, and so often was a common grain aphis (*Macrosiphum granaria*) confused with this southern insect that it was deemed expedient to make a special report to the Governor upon this and other grain aphids. This was done, and was issued in printed form in March, 1908. Illustrated with colored plates and fine drawings, showing not only the green bug and other lice which resembled them, but also its chief parasite, this report was intended to familiarize our farmers and others with the appearance of this insect, and to allay any fears which may have been caused by exaggerated statements.

The report was extensively circulated, and to spread the information still further, it was later reproduced as Bulletin 108 from the Experiment Station. In this bulletin the work of this department, as far as it related to the green bug, was summarized as follows:

"The unusually mild winter and cool spring of 1907 in the southern states, enabling the 'green bug' to multiply without interruption from its parasite, were the causes of the outbreak last season in the South. Minnesota has long, cold winters and warm summers. The first factor renders it impossible for this pest to multiply in the winter or early spring as it does in parts of the South. The second factor is favorable for the rapid increase of its principal parasite, which is found in this state, and which even in the South, in ordinary years, keeps the pest in check. Therefore, in all probability, the Northwest will never have cause to fear an outbreak of the 'green bug' or any other louse affecting grain."

We see no reason, from observation and field work during the summer of 1908, to qualify that statement.

One significant discovery has been made here during the course of the year, since the publication of the above report, which has a direct bearing upon the occurrence of this so-called "southern form," and may oblige us to change our views to a certain extent as regards its being a visitor from the vicinity of the Mason and Dixon line. On April 7th, 1908, eggs were found on grasses (*Elymus canadensis* and *Beckmani sp.*) in the river gorge near St. Anthony Park. These eggs had been laid between the leaves and the stem. They hatched April 14th and proved to be this species, showing that the eggs may survive our winters. On April 23rd more eggs of this species were found at St. Anthony Park on *Beckmani,* and in the same location on the plant. Most of these eggs were dead, though some were alive. The eggs of Toxoptera then may survive our winters; the finding of a young larva of this species, evidently a young "stem mother," in the same vicinity as the April 7th discovery, corroborates this belief.

On July 27th a winged and wingless female were found at Breckenridge on volunteer oats. This has a significant bearing upon our finding winged forms here in 1907. In other words, they may have been permanent residents here at that time, though it is probable, or at least possible, that we were first infested by winged migrants from the country south of us. At Moorhead the next day young specimens were found in considerable abundance on volunteer oats and at Hallock, Minn., on July 29th, they were found on oats and on the lower leaves of barley. July 30th they were found on the lower leaves of young barley near Crookston, and were numerous enough, on one plant at least, to turn its leaves white. Eighteen lice of this species were counted upon this leaf. Fifty per cent of the plants examined were infested, and in every case the insects were inside of the lower leaves next the stem, frequently six or seven on one plant. Some winged specimens were found.

The eggs from which the above insects came were, of course, laid in the fall of 1907. In our experimental garden at the Station we secured eggs in barley somewhat earlier than November 4th, 1907. Like many other aphid eggs, they were light green at first, changing to black in a few days.

The questions which at once suggest themselves are: "How long has this been going on?" "Were the aphids which were found last year as far north as our Canadian border, not native here, from

the original stem mother, rather than descendants of a migrant form from the South?"

In other words, it may be that in place of calling this insect the Southern Grain Aphis, we shall have to make use of the term already applied to it by numerous scientists, namely, the "Spring Grain Aphis," and regard it as a permanent resident in Minnesota. We see, however, no reason to change our views as to its comparative harmlessness in this state under our normal climatic conditions.

This insect, in the past two years, has been found pretty generally scattered over the wheat growing portions of the state.

In the insectary several series of Toxoptera were carried through from the egg, the experiments showing how prolific the "Green Bug" (other plant lice have this characteristic strikingly developed) may be. The record of three of these series are here given. The eggs used were those found in the river gorge April 7th, above referred to. They hatched on April 14th. From these we took one, a "stem mother" of course, and taking the first young produced in each generation, obtained the following results. By "first generation" we mean this stem mother. Her young would be the second generation, and we took the first individual produced from them to represent the third generation, and so on. In other words, in the following table the dates indicate the date of birth (of hatching in the case of the stem mother) of the first of each generation, and in the column to the right of this the number of young produced by this individual:

SERIES D—

1st	Generation (stem mother)	April	14—41	young, Experiment No.	95
2nd	"	"	24—73	" " "	102
3rd	"	May	5—67	" " "	112
4th	"	"	16—69	" " "	129
5th	"	"	25—76	" " "	137
6th	"	June	4— 6	" " "	156
7th	"	"	15—36	" " "	174
8th	"	"	24—73	" " "	192
9th	"	July	2—70	" " "	216
10th	"	"	10—56	" " "	230
11th	"	"	17—57	" " "	241
12th	"	"	24—92	" " "	252
13th	"	"	29—78	" " "	268
14th	"	Aug.	4—52	" " "	299
15th	"	"	12—85	" " "	324
16th	"	"	21—29	" " "	346
17th	"	"	25—96	" " "	360

Taking these seventeen generations, we find that the sum of the young produced in each by the first individual born amounts to 959, an average of 57 for every generation.

SERIES C—

1st	Generation.	Jan. 22— 8,	Experiment No.	19
2nd	"	Feb. 3—62,	" "	23
3rd	"	Feb. 21—26,	" "	39
4th	"	Mar. 6—40,	" "	53
5th	"	Mar. 20—40,	" "	65
6th	"	Apr. 1—67,	" "	74
7th	"	Apr. 14—52,	" "	90
8th	"	Apr. 22—44,	" "	99
9th	"	May 9—44,	" "	115
10th	"	May 16—28,	" "	127
11th	"	May 26—38,	" "	139
12th	"	June 6— 1,	" "	160
13th	"	June 24—31,	" "	193
14th	"	July 6—75,	" "	225
15th	"	July 15—31,	" "	235
16th	"	July 22—35,	" "	248
17th	"	July 28—47,	" "	264
18th	"	Aug. 6—16,	" "	301
19th	"	Aug. 24—61,	" "	354
20th	"	Aug. 31—68,	" "	368

This gives a total of 814, or an average of 41 young for every generation.

SERIES B—

1st	Generation.	Jan. 22—69,	Experiment No.	8
2nd	"	Feb. 3—58,	"	24
3rd	"	Feb. 21—58,	" "	38
4th	"	Mar. 2—38,	" "	46
5th	"	Mar. 16—25,	" "	60
6th	"	Mar. 30—28,	" "	71
7th	"	Apr. 14—55,	" "	89
8th	"	Apr. 24—51,	" "	101
9th	"	May 6—44,	" "	113
10th	"	May 16—15,	" "	128
11th	"	May 25—64,	" "	138
12th	"	June 19—51,	" "	187
13th	"	June 26—59,	" "	200
14th	"	July 6—56,	" "	224
15th	"	July 13—16,	" "	231
16th	"	July 15—50,	" "	236
17th	"	July 24—57,	" "	251
18th	"	July 30—81,	" "	272
19th	"	Aug. 4— 54,	" "	300
20th	"	Aug. 12—34,	" "	325
21st	"	Aug. 20—68,	" "	345
22nd	"	Aug. 31—65,	" "	367

This gives a total of 1,117, or an average of 51 young per generation in Series B, and the average number of young produced by the first form of each generation of the three above series, D. C and B, is 50.

Obtaining these results has called, as indicated by the table, for a large number of individual experiments in the insectary, 17 in the case of D, 20 in the case of C, and 22 in the case of B, and has demanded most careful and painstaking effort. As stated above, D was started from an egg collected in the river gorge near St. Anthony Park. Series B and C were started from eggs hatched early in the insectary. D shows a greater prolificacy than either B or C. This may be due to the fact of a longer period in the egg, more natural conditions, etc. The table shows that reproduction during July and August was somewhat more rapid than in the earlier part of the season.

It must be borne in mind that in the above breedings we have taken only the first individuals in each generation. If it were possible to compute the entire number of lice coming from a single stem mother with which we started in each series, the sum total would be enormous, beyond belief.

To give an idea of the prolificness of plant lice of all kinds, we quote from Reaumer's statistics, from which it is shown that a single stem mother, in one season of uninterrupted breeding, may give rise to 5,904,900,000. To appreciate what an enormous number this is, we quote from one of Dr. Felt's Reports the following illustration: "If these individuals were ranged four abreast, the usual arrangement of a marching column of human beings, and each file closely behind the other, we would have an army long enough to encircle the globe at the equator, and enough would remain to stretch across this continent. In other words, an army 27,952 miles long." Fitch, formerly entomologist of Illinois, estimated the number of aphids (cherry aphids) living at one time on a small cherry tree to be 12,000,000.

The eminent Huxley has vividly demonstrated this wondrous fecundity, after careful calculation, estimating that in ten generations of uninterrupted breeding of plant lice, starting from one individual, there would result a mass of organic matter equal to the bulk of 500,000,000 human beings, or about the population of the Chinese Empire. Fortunately, climatic conditions and parasitic and predaceous enemies keep plant lice in check.

THE ENGLISH GRAIN LOUSE.

Macrosiphum granaria Buck.

The following additional notes on this species have been taken this summer. For the work of 1907 the reader is referred to Bulletin No. 108 of this Experiment Station:

The complete life history of this louse so common in our grain fields has not been worked out, and it is a problem assigned to the Minnesota entomologist by the Department of Agriculture at Washington. At least another season will be required to obtain final results. Our findings show very conclusively the varieties of food plants affected, its very general distribution over the state, the hardiness of the species (indicated by our finding viviparous females with young on December 10th),* the probable first appearance of winged migrants by means of which the species is principally scattered, and the amount of parasitism, upon which we largely depend to keep this pest in check.

In considering the following notes one should bear in mind the method of reproduction of all of these aphids, viz.: A "stem mother" hatching in the spring from an egg which has gone through the winter then from ten to twenty generations (approximately) of females, some of which are winged ("migrants"), and no males until fall, at which time, and only then, mating takes place, and eggs are laid (the only eggs in the series) which will hatch into stem mothers the following spring.

General suggestions for the control of all grain aphids will be given at the end of this article.

December 19, 1907. Winged and wingless viviparous forms found at Experiment Station on plots of winter wheat and on rye.

December 22. No sexual forms; a few winged forms found on the above plots. At least one-half of the lice found were dead. This would seem to indicate that the sexual form appears very late in the season.

January 19, 1908. No lice found on winter wheat. Temperature at time of examination 40 degrees above zero. Has been below zero only twice during the winter up to this date, the thermometer registering on an average from 18 degrees to 32 degrees.

February 15. No live aphids and no eggs found on experimental plots of winter wheat.

April 23. A young (nymph) found on grass.

*The same observation made Dec. 10th, 1908, at which time no eggs could be found. The temperature has been as low as —5° F. for a short period.

May 11 and 12. Supposedly specimens representing first brood found on Station ground on fall rye and winter wheat, none on spring grain. Also a few specimens on grass below Lake street bridge. These findings were our first this season, though we looked for them May 5th, 6th and 7th at Albert Lea and Mankato.

On May 27th winged and wirgless females were found producing young on oats and on grasses at the Station. Evidently the first migrant form appears at this date.

June 6. Found in small numbers along with its principal parasite, at Albert Lea, in oat field. Oats about six inches high.

June 9. Owatonna; present in small numbers on grain.

June 26. In varying abundance at Monticello, on oats, wheat, barley, pigeon grass and corn.

June 28. Numerous on small grains at St. Anthony Park. Winged forms more numerous than wingless.

June 29. Found on rye at Red Wing. Many individuals parasitized. Also found at this date on barley and Bromus.

July 5. Present in small numbers on corn at Mora, Minn., and abundantly on oats, both winged and wingless; one individual on quack grass. Three specimens observed to be attacked by mites.

July 6. Winged and wirgless forms found in small numbers on oats and volunteer barley.

July 7. Grass Lake; not found on rye, but present on heads and leaves of barley, and both winged and wingless forms found on oats.

July 9. North Branch; present on oats, wheat and barley; most abundant on oats.

July 18. Winged forms without young on corn.

July 20. Parasitized individuals, winged and wingless, on heads of wheat at St. Anthony Park.

July 25 and 26. On corn and wheat at Olivia, Minn., winged, wingless and young, and to some extent on oats.

July 26. Ortonville; not found on corn, barley or blue stem wheat.

July 27. Breckenridge; on heads of blue stem and *Hordeum pubatum.*

July 28. Moorhead; small numbers on barley and wheat.

July 29. Hallock; a few on heads of wheat and on leaves of barley.

July 30. Crookston; in small number on oats, barley, wheat and *Hordeum pubatum.*

Insectary Notes: On Aug. 26th this species bred on wheat e insectary was in the ninth and tenth generations from the in- uals first taken by Vickery in the spring (Apr. 23?).

Pursuing the same plan as with the "green bug," taking the first ring of each generation, we found it averaged from fourteen to en young as follows:

A.

1st	Generation.		—18	young,	Experiment	No. 119
2nd	"	May	14—26	"	"	" 123
3rd	"	May	25—22	"	"	" 136
4th	"	June	5—17	"	"	" 158
5th	"	June	15—12	"	"	" 173
6th	"	July	1—11	"	"	" 228
7th	"	July	22— 6	"	"	" 249
8th	"	July	30—16	"	"	" 271
9th	"	Aug.	22—28	"	"	" 352
10th	"	Sept.	1— 3	"	"	" 372
11th	"	Sept.	15—14	"	"	" 402
12th	"	Sept.	22—*4	"	"	" 413
13th	"	Oct.	16—*	"	"	" 422

The 12th and 13th generations are still reproducing viviparously his is written (Oct. 19). Taking the first eleven generations of es A we have an average of about sixteen young from the first pring of each generation.

B.

1st	Generation,		—27	young,	Experiment	No. 120
2nd	"	May	19—25	"	"	" 130
3rd	"	June	5—38	"	"	" 157
4th	"	June	15— 2	"	"	" 172
5th	"	June	26— 7	"	"	" 199
6th	"	July	7— 5	"	"	" 229
7th	"	July	14— 8	"	"	" 234
8th	"	July	29—19	"	"	" 269
9th	"	Aug.	10— 7	"	"	" 317
10th	"	Aug.	24— 1	"	"	" 353
11th	"	Sept.	11— 9	"	"	" 391
12th	"	Sept.	21—18	"	"	" 407
13th	"	Oct.	5— *	"	"	" 416

The thirteenth generation is still producing young (Oct. 19). Tak- the first twelve generations of this series, we find that the average ıber of young from the first individual of each generation is 14, of both series, A and B, is 15. Comparing this with the average 0 obtained with the "green bug," one is at once struck with the ıendous productiveness of the latter, far in excess of the "north- form, *M. granaria.*

This wonderful fecundity on the part of the Green Bug has a most serious aspect to farmers who live in the South, where reproduction of grain aphids begins very early in the season. If the cold winters of Minnesota could be eliminated our grain fields would be in great danger.

We have yet to find the dates and location of egg laying of *M. granaria* in the fall, evidently quite late, for on Dec. 10, 1907, we found winged and wingless females and young on winter wheat, an indication that the egg-laying forms of this species appear very late in the season. The temperature had been down as low as 10° above zero, and these individual lice had been covered with snow.

THE EUROPEAN GRAIN LOUSE.

Siphocorynae avenae Fab.

This insect common on our grain, also believed to be the same found on the apple under another name ("Green Aphis") was discussed on pages 15 and 16 of the report and bulletin previously alluded to. It was found affecting leaves and young stems of wheat, oats, barley and rye, and later found on the heads of the same grains. It was also found on pigeon grass and volunteer grains, and in the fall on winter wheat and rye. In 1907 it was found pretty generally distributed over the state.

In 1908 it was found as follows:

July 5, Mora, on quack grass, where, by the way, it was attacked by a small red mite. July 10th it was found on oats at St. Anthony Park. On July 19 at the same place "on apple, curling the leaves of the new growth and doing considerable damage."

July 27. Breckenridge: Young of this species found on volunteer oats, inside the leaf sheaths, and on the 28th at Moorhead on volunteer oats in stubble inside the unopened terminal leaves.

The following table shows insectary work on this species, beginning January 10th. It is interesting to note that in this series there was no intervening egg stage; in other words, the generations were produced continuously with no break from the insects of the preceding year. Further, the insects through which these generations came had been subjected in the cold room of the insectary, to zero temperature during the last of December and first part of January.

1st	Generation,	Jan.	10— 9	young,	Experiment	No. 4
2nd	"	Jan.	11—28	"	"	" 5
3rd	"	Jan.	22— 6	"	"	" 10
4th	"	Feb.	3— 9	"	"	" 26
5th	"	Feb.	21—16	"	"	" 36
6th	"	Mar.	2—28	"	"	" 45
7th	"	Mar.	11— 6	"	"	" 54
8th	"	Mar.	25—Incomplete		"	" 67

An average of fifteen young from the first born of each generation. These tables are given for the purpose of affording a comparison of productiveness of these grain aphids, and of giving an idea of the frequency of the broods. As previously stated, should we attempt to enumerate all the young from one "stem mother" our figures would take us into the billions, or higher.

THE CORN LEAF LOUSE.

Aphis maidis Fitch.

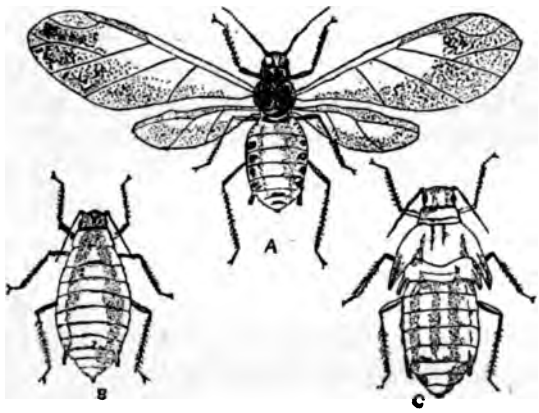


Fig. 26. Corn leaf louse, *Aphis maidis*, winged and wingless females and pupa. After Forbes.

This louse, primarily regarded as a corn insect, also attacks grain, and was found at Crookston on July 30th, inside the terminal leaves of young barley, appearing to be the most numerous aphid in the field. As many as thirty individuals were found in a colony, located inside or just at the base of the terminal leaf. It was also found on tassels of corn at Crookston.

On July 6 a very few were observed on corn at Mora. But on July 18 winged and wingless individuals were found in considerable numbers at St. Anthony Park on young corn tassels, and plenty of the

wingless form were found the following day on *Panicum capillare* in the same locality. At Olivia on July 25th and at Ortonville on July 26th winged females and larvæ were found inside the folded corn leaves and on young tassels.

Manifestly if corn has suffered severely from the attacks of this pest, it is not advisable, from the facts above stated, to use the same field for corn the following year.

Macrosiphum trifolii.

May 17: On corn (winged and wingless females) at St. Anthony Park.

July 13: Supposedly this species in oats at St. Anthony Park.

July 28: On plantain adjoining a corn field at Olivia. One of the larvae was attacked by mites.

GENERAL REMEDIES FOR LICE ON GRAIN.

As intimated in the special report and bulletin referred to above, parasites keep grain plant lice in check in normal years, and owing to climatic conditions here we need probably never fear serious loss from these pests. Among their enemies are to be included certain predaceous flies which lay their eggs among the colonies, these eggs hatching into hungry maggots, which consume large quantities of lice. Then too, the "lady bird" beetles, both the adults and young grubs eat an enormous number, as do also the larvae of lace-winged flies, but the hosts of tiny winged parasites, although few in number of species, are the most useful instruments in aiding the farmer. From the fact that the winter eggs of the above plant lice are found on various grasses and on different volunteer grains near or in the stubble, it is evident that keeping the edges of grain fields clean and free from such growths would be an aid. The very usual practice of fall plowing of stubble is, of course, of great value.

This division of the Experiment Station has been working upon insects affecting clover and alfalfa, the results of which will be published later.

REPORT ON NURSERY INSPECTION IN 1908.

Fifty-nine nurseries were inspected this year, and found for the most part to be in excellent condition.

The so-called common Apple Aphis or Green Aphis, was abundant as it always is, and so was the Apple Leaf Hopper, though the latter was not so abundant as in previous years. The Buffalo Tree Hopper has done considerable damage in nurseries, many nurserymen mistaking the work of this insect for hail. The Scurfy Scale and Oyster Shell Scale were met with, the former having practically killed a small grove of willows. One of the Stalk Borers in one large nursery destroyed or badly injured over a thousand two year old ash trees. The plum Curculio has evidently been active in plum and apple orchards. Careful search was made in every nursery for the Strawberry Root Louse, but it was not found. Anthracnose of the raspberry evidently is abundant in all the nurseries, as is also a disease attacking seedling Boxelders. Less Pear Blight or Fire Blight was seen this year than in many previous seasons. The inspector is watching for Crown Gall on Raspberries, but at the time of the inspection of nurseries it was not in evidence. There is but little rust on strawberries. Hail has done some damage in several nurseries, but as stated above, some nurserymen attributed the work of the Buffalo Tree Hopper as the result of hail.

The list of nurseries inspected, with their certificate numbers is appended.

There has been some conflict between express agents and consignees in this state, the former not realizing exactly what is regarded as "nursery stock." In a few instances stock shipped in here from greenhouses outside of the state has been lost through the diligence of the express companies. It is much better to have the express companies eager to co-operate with us in keeping out uninspected stock, than the reverse. It would be wise, however, for any Minnesota nurserymen ordering stock outside of the state to have the same properly labeled if it comes from a greenhouse. This will avoid any holdup of stock in Minnesota. Our nurserymen in shipping to patrons outside of the state should do the same thing. It is the duty of all trans-

portation agents to see that every shipment of nursery stock into Minnesota is accompanied by a certificate of inspection, legally executed by the inspector. Any violation of the law should be reported to the State Entomologist at the Experiment Station, St. Anthony Park. Any stock coming from a nursery is to be regarded as nursery stock, namely trees, plants, vines, cuttings or buds, or strawberry plants, or ornamentals grown in a nursery, but does not include stock grown in greenhouse.

Since there have been numerous changes in laws relative to nursery inspection and nursery shipments in the different states since we published the same, we include here a compilation of the latest laws in the different states.

Alabama: Persons shipping stock into the state must file a signed duplicate certificate of inspection and obtain official tags, which must be placed on each shipment, in addition to a copy of the certificate. Cost of tags, 60 cents per hundred, or $2.25 per thousand. Five cents per hundred must be added for postage. Mr. R. S. Mackintosh, State Horticulturist, Auburn, Ala. (Act of 1903.)

Arizona: The University of Arizona Agricultural Experiment Station is authorized to inspect all palms or palm stock growing in or shipped into the Territory. Prof. R. H. Forbes, Director of Agricultural Experiment Station, Tucson, Ariz. (Act of 1907.)

Arkansas: Shipments must bear a certificate of inspection. Mr. C. F. Adams, State Inspector, Fayetteville, Ark. (Act of 1903.)

California: Shipments of stock sent into the state are subject to inspection and must bear the name of the consignor and consignee and a statement of where the stock was grown. Notice of shipments should be made to Hon. J. W. Jeffrey, Commissioner of Horticulture, Sacramento, Cal.

Colorado: Shipments into the state must be inspected by county inspectors. (Amended act of 1907.)

Connecticut: Shipments of stock into the state must bear certificates of inspection issued by a state or government officer, and a statement by the owner that they have been thoroughly fumigated. Dr. W. E. Britton, State Entomologist, New Haven, Conn. (Amended act of 1903.)

Delaware: Shipments into the state must be accompanied by a certificate of inspection of a state or government official and the owner or shipper must certify that the stock has been fumigated. Delaware nurserymen are required to fumigate their stock. Mr. Wesley Webb, Dover, Del. (Amended act of 1907.)

Florida: It is unlawful for any non-resident person or persons, corporation or firm to sell or offer for sale nursery stock in the state of Florida without first having paid a license tax of $25 annually to the collector of revenues of the county in which the stock is sold or offered for sale. Upon payment of this amount a license will be issued by the county judge. (Act of 1905.) It is unlawful for any person to knowingly sell or give away diseased nursery stock or seeds in the state of Florida. Dr.

E. W. Berger, Entomologist, Florida Agricultural Experiment Station, Gainesville, Fla. (Act of 1906.)

Georgia: Shipments into the state must be accompanied with certificates of inspection and copies of the official tags of the State Board of Entomology. These may be obtained by submitting a duplicate of the official certificate of inspection and a statement that all stock shipped into the state will be properly fumigated. Tags are furnished at cost. Mr. E L. Worsham, State Entomologist, Atlanta, Ga. (Act of 1900.)

Hawaii: Shipments are subject to the regulations of the Board of Commissioners of Agriculture and Forestry and are subject to inspection and quarantine on arrival at Honolulu, which is the only port where they are allowed to be landed. For application blanks for inspection and special information, address Hon. C. S. Holloway, Secretary, Honolulu, Hawaii.

Idaho: Persons desiring to sell or ship stock into this state must file a bond in the sum of $1,000 with the State Board of Horticulture, conditioned on the faithful compliance with the requirements of the law, and secure a permit to do business in the state. Shipments must bear official certificates of fumigation, and the name of the grower and consignee must appear on the package. Mr. J. R. Field, State Horticultural Inspector, Boise, Idaho.

Illinois: Shipments into the state must be accompanied with certificates of inspection. The State Entomologist is required by law to furnish annually to Illinois nurserymen a list of state and government inspectors whose certificates may be received as equally valid with his own, and the nurserymen receiving stock under such certificates are authorized to substitute the Illinois certificate of inspection. Agents and dealers must file sworn statements with copies of certificates showing the source from which their stock is obtained, for the approval of the State Entomologist. Dr. S. A. Forbes, State Entomologist, Urbana, Ill. (Act of 1907.)

Indiana: Stock shipped into the state must be accompanied with certificates of inspection, and each shipment must bear the name of the consignor and consignee. It is unlawful for any transportation company to accept for shipment or to deliver any uncertified nursery stock. Mr. Benjamin W. Douglass, State Entomologist, Indianapolis, Ind. (Act of 1907.)

Iowa: Shipments into the state must be accompanied by official certificates of inspection, copies of which should be previously filed for approval with the State Entomologist. Prof. H. E. Summers, State Entomologist, Ames, Iowa. (Amended act of 1906.)

Kansas: Stock shipped into the state must be accompanied by certificates of inspection. Prof. S. J. Hunter, Lawrence, Kan., and Prof. T. J. Headlee, Manhattan, Kan., State Entomologists. (Act of 1907.)

Kentucky: Shipments into the state must be accompanied with official certificates of inspection, copies of which should be filed with the State Entomologist. Prof. H. Garman, State Entomologist, Lexington, Ky. (Act of 1897).

Louisiana: Shipments sent into the state must be accompanied with official certificates of inspection. When a shipment containing two or more orders is sent to an agent or dealer for delivery to different persons,

a certificate must accompany each individual order. Mr. Wilmon Newell, Entomologist, State Crop Pest Commission, Baton Rouge, La. (Act of 1903, Regulations of State Crop Pest Commission, approved April 11, 1917.)

Maine: Shipments into the state must bear official certificates of inspection or affidavits that the contents have been fumigated in a manner approved by the state inspector of the shipping point. Hon. A. W. Gilman, Commissioner of Agriculture, Augusta, Me. (Act of 1907.)

Maryland: Stock sent into the state must bear the name of the consignor and consignee and a certificate of inspection. Duplicate certificates shou'd be filed with the State Entomologist. Prof. T. B. Symons, State Entomologist; Prof. J. B. S. Norton, State Pathologist, College Park, Md. (Act of 1898.)

Massachusetts: Stock sent into the state must bear a certificate of inspection or an affidavit of fumigation. Dr. H. T. Fernald, State Nursery Inspector, Amherst, Mass. (Amended act of 1907.)

Michigan: Nurserymen selling stock in this state must pay a license fee of $5 and furnish a bond of $1,000, with satisfactory sureties. Shipments must be accompanied with certificates of inspection, and, if of species subject to the attack of the San Jose Scale, certificates by the nurserymen that the stock has been properly fumigated. Prof. L. R. Taft, State Inspector of Orchards and Nurseries, Agricultural College, Michigan. (Amended act of 1905.)

Minnesota: Nursery stock shipped into the state must bear a certificate of inspection. Carrying companies liable. There is an annual inspection of nurseries shipping stock out of the state. Prof. F. L. Washburn, State Entomologist, St. Anthony Park, Minn. (Act of 1903.)

Mississippi: Before shipping stock into the state a copy of an official certificate of inspection must be filed with the Entomologist of the Experiment Station, which must state that in addition to the regular inspection the stock has been fumigated under the direction of the official issuing the certificate. Failure to comply with this requirement renders the stock liable to confiscation and destruction. All shipments must be accompanied with such a certificate. Prof. Glenn W. Herrick, Experiment Station, Agricultural College, Miss. (Act of 1908.)

Missouri: Stock shipped into the state must bear the name of the consignor and the consignee and a statement of the contents and an official certificate of inspection. Prof. J. M. Stedman, State Entomologist. Agricultural Experiment Station, Columbia, Mo.

Montana: All stock brought into the state must be unpacked, inspected, and, if necessary, fumigated at one of the designated quarantine stations, viz.: Miles City, Billings, Dillon, Missoula, Kalispell, Great Falls, Troy, Plains, Glasgow or Thompson Falls. Nursery stock may be inspected, and, if necessary, fumigated at other points of delivery on payment of all cost. To sell or deliver nursery stock it is necessary first to obtain a license by paying a fee of $25 and by filing with the Secretary of the State Board of Horticulture a bond in the sum of $1,000 annually. Notice of shipment, including an invoice of stock, must be sent to Mr. Joseph W. Wallisch, Secretary, Montana State Board of Horticulture, Hirbour Block, Butte, Mont. (Act of 1899.)

Nebraska: No nursery inspection law. Local nurseries inspected and certificates issued by Prof. Lawrence Bruner, Acting State Entomologist, Lincoln, Neb.

Nevada: No law.

New Hampshire: Stock shipped into the state must bear a certificate of inspection or a statement containing an affidavit that it has been properly fumigated. Prof. E. D. Sanderson, State Nursery Inspector, Durham, N. H. (Act of 1903.)

New Jersey: Stock shipped into the state must be accompanied with a certificate of inspection and a statement from the shipper that it is a part of the stock inspected and whether it has been fumigated with hydrocyanic-acid-gas. Dr. John B. Smith, State Entomologist, New Brunswick, N. J. (Act of 1903.)

New Mexico: No law relating to nursery inspection.

New York: Nursery stock shipped into the state must be accompanied with an official certificate of inspection and must be fumigated before being sold or planted. Hon. Chas. A. Wieting, Commissioner of Agriculture, Albany, N. Y. (Act of 1903.)

North Carolina: Shipments sent into this state must bear official certificates of inspection and should be fumigated and a statement to that effect signed and attached by the consignor. Duplicate certificates must be filed with the State Entomologist. Franklin Sherman, Jr., State Entomologist, Raleigh, N. C. (Act of 1897.)

North Dakota: No law.

Ohio: Shipments must be accompanied with official certificates of inspection or fumigation. Agents and dealers must file sworn statements as to sources from which their stock is obtained. Mr. N. E. Shaw, Chief Inspector, Department of Agriculture, Columbus, Ohio.

Oklahoma: The owners or operators of nurseries who desire to ship stock into the state of Oklahoma are required to make an application for a permit. This will be issued by the Board of Agriculture upon the filing of a duplicate certificate of inspection or the report of inspection from the state inspector who examined the stock, and in addition the application must be accompanied by a remittance of $5. If satisfactory, the Board will issue a permit over the signature of its secretary, and in addition to the above may require further evidence of integrity to establish the responsibility and good faith of the applicant. All shipments must be accompanied by a tag on which is printed a copy of this permit over the facsimile signature of the secretary of the Board. All agents canvassing for nurseries located outside the state are required to carry a duplicate of the permit of their principals, which duplicate is issued upon payment of $1. Quotations on tags will be forwarded upon application to the secretary. Address all communications to Oklahoma State Board of Agriculture, C. F. Barrett, Secretary, Guthrie, Okla. (Act of 1905.)

Oregon: Stock is subject to inspection on arrival at quarantine stations. Mr. H. W. Williamson, Secretary, State Board of Horticulture, Portland, Ore. (Amended act of 1905.)

Pennsylvania: Shipments of nursery stock into the state must be plainly labeled on the outside with the name of the consignor and consignee, and a certificate showing that the contents have been inspected and that the stock (excepting conifers and herbaceous plants) therein contained have been properly fumigated. Dealers in nursery stock are furnished certificates under certain restrictions. Transportation companies are required to reject all stock entering the state unless certificates of inspection and fumigation are attached. Prof. H. A. Surface, Economic Zoologist; Mr. E. B. Engle, Inspector, Harrisburg, Pa. (Act of 1905.)

Porto Rico: Nursery stock will be received only through three ports of entry, namely, San Juan, Ponce and Mayaguez, and must be accompanied with an official certificate of inspection. It is subject to inspection by local inspectors on arrival at said ports of entry. Inspectors are appointed by the Governor. (Act of 1905.)

Rhode Island: Shipments must be accompanied with certificates of inspection or affidavits of fumigation. Mr. A. E. Stene, State Nursery Inspector, Kingston, R. I. (Act of 1904.)

South Carolina: A duplicate certificate of inspection must be filed with the State Entomologist and an official tag of the State Board of Entomology secured by nurserymen desiring to ship stock into the state. This tag and an official certificate of fumigation must be attached to all shipments. Prof. C. E. Chambliss, State Entomologist, Columbia, S. C. (Act of 1903.)

South Dakota: Shipments into the state must be accompanied with official certificates of inspection. A license fee of $10 must be paid to secure a permit to ship stock into the state. Mr. Robert Mathieson, State Entomologist, Brookings, S. Dak. (Act of 1907.)

Tennessee: A certificate of inspection signed in person by the inspector or the State Entomologist must be filed in the office of the Tennessee State Board of Entomology, Knoxville, Tenn., previous to all shipments. All nursery stock must be fumigated and a tag indicating the same placed upon each shipment. Prof. H. A. Morgan, State Entomologist, Knoxville, Tenn. (Act of 1905.)

Texas: Duplicate certificates of inspection must be filed, and all shipments must bear certificates of inspection. Hon. R. T. Milner, Commissioner of Agriculture, Austin, Tex. (Act of 1905.)

Utah: All stock shipped into the state must bear an official certificate stating that it has been fumigated with hydrocyanic-acid gas. Nurserymen doing business in the state must pay a license fee and file a bond with the State Board of Horticulture in the sum of $500. License fees are graded as follows: Any annual business below $1,000, $5 per year; over $1,000 and under $3,000, $10 per year; over $3,000 and under $10,000, $25 per year; over $10,000, $50 per year. Mr. J. Edward Taylor, Secretary, State Board of Horticulture, Salt Lake City, Utah.

Vermont: No law.

Virginia: Duplicate certificates of inspection must be filed by nurserymen shipping stock into the state and official tags obtained from the Board of Crop Pest Commissioners; also a registration fee of $20 must be paid. Tags furnished at cost. Mr. J. L. Phillips, State Entomologist, Blacksburg, Va. (Amended act of 1903.)

Washington: Before soliciting or engaging in selling nursery stock in this state a bond of $1,000 and a license fee of $5 must be paid by nurserymen and a license fee of $2.50 by agents and dealers. Notice must be sent previous to the shipment of stock, giving the names of the nurserymen and the places at which it is to be delivered. Hon. F. A. Huntley, Commissioner of Horticulture, Tacoma, Wash. (Act of 1907.)

West Virginia: All stock shipments into the state must be accompanied by an official certificate of inspection and fumigation. Notice of shipments must be sent, ten days before the time of delivery, to the Director of the West Virginia Experiment Station, stating the number of trees in each consignment, the place from which such are to be shipped, and their destination. Agents and dealers who sell stock must secure a license from the assessor in the county where the stock is sold and pay a fee of $10 to the sheriff of the county. Prof. J. H. Stewart, Director of Agricultural Experiment Station, Morgantown, W. Va. (Amended acts of 1905 and 1907.)

Wisconsin: Stock shipped into the State must be accompanied with an official certificate of inspection. Prof. E. P. Sandsten, Agricultural Experiment Station, Madison, Wis. (Act of 1907.)

Wyoming: Any person or firm wishing to do business in the state must first obtain a license. Licenses are issued on application, for a period terminating on July 1 of the next succeeding inspection year (approximately two years.) All applications must be accompanied by the license fee ($25), a bond in the sum of $500 conditioned that the principal will faithfully obey the law of the state of Wyoming, and by a certified certificate of inspection from an authorized inspector in the state from which shipments are to be made. On receipt of these, the secretary of the State Board issues authorized shipping tags (at cost). Nursery stock may not enter the state and transportation companies may not deliver unless such tags be attached to each and every box, bundle or bale. For circular of detailed information address Prof. Aven Nelson, Secretary State Board of Horticulture, Laramie, Wyo. (Act of 1905.)

Canada: Shipments of stock into Canada are unpacked and fumigated by government inspectors and must arrive within the time specified at the following ports of entry: St. Johns, Quebec; Niagara Falls, Ontario, and Windsor, Ontario, from March 15 to May 15, and from September 26 to December 7, St. John, New Brunswick, and Winnipeg, Manitoba, from March 15 to May 15, and from October 7 to December 7; Vancouver, British Columbia, from October 1 to May 1. Dr. James Fletcher, Dominion Entomologist, Ottawa, Ont.

Two hundred and fourteen dollars and ninety-one cents ($214.91) was received for expenses and fees, and the same turned into the State Treasury to be used for combating injurious insects.

1908	Name and Town.	Cert. No.	Cash.
July 6	West Concord Nursery, West Concord	212	$2.90
July 6	Dodge County Nursery, Mantorville	213	2.90
July 6	Byron Nursery, Byron	214	2.90
July 7	Ritter Berry Farm, Plainview	215	4.25
July 7	Pleasant Valley Nursery, Winona	216	4.75
July 8	Vinegar Hill Nursery, Rushford	217	4.75
July 8	Preston Nursery, Preston	218	4.75
July 9	Spring Valley Nursery, Spring Valley	219	4.75
July 9	Turtle Creek Nursery, Austin	220	4.75
July 10	Farmers' Seed Co., Faribault	221	2.00
July 10	Campion Nursery, Faribault	222	2.00
July 10	Brand Nursery, Faribault	223	2.00
July 10	Andrews' Nursery, Faribault	224	2.00
July 13	Deerfield Nursery, Deerfield	225	4.50
July 14	Mitchell Nursery, Owatonna	226	3.25
July 14	Clinton Falls Nursery, Owatonna	227	4.25
July 14	Albert Lea Nursery, Albert Lea	228	2.00
July 14	Wedge Nursery, Albert Lea	229	3.00
July 14	Minnesota State Nursery, Albert Lea	230	2.00
July 14	Gopher State Nursery, Albert Lea	231	2.00
July 15	Winnebago Nursery, Winnebago City	232	3.50
July 15	McKisson's Fairmont Nursery, Fairmont	233	4.00
July 15	St. John Nursery Co., Fairmont	234	4.00
July 16	Amber Lake Nursery, Fairmont	235	4.00
July 16	Jackson Nursery, Jackson	236	4.50
July 16	Sherburne Nursery, Sherburne	237	4.50
July 17	Luverne Nursery, Luverne	238	4.50
July 17	Northwestern Nursery, Pipestone	239	4.50
July 17	Kanarr[illegible] Nurseries, Adrian	240	4.50
July 21	Twin City Nursery Co., Minneapolis	241	2.60
July 21	Hayes Plant & Seed Co., St. Paul	242	1.25
July 22	Rose Hill Nursery, Minneapolis	243	1.50
July 24	Isaac Nursery Co., Lake City	244	4.50
July 24	Isaacson Nursery Co., Lake City	245	4.50
July 24	Tillson Nursery, Lake City	246	3.00
July 24	County Line Fruit Farm, Lake City	247	3.50
July 28	Chas. Hawkinson Nursery, Waseca	248	1.50
July 28	Stephens' Nursery, Excelsior	249	1.50
July 31	Vine Grove Nursery, Minneapolis	250	2.60
Aug. 14	Hutchinson Nurseries, Hutchinson	251	5.20
Aug. 27	Markato Nursery, Markato	252	5.50
Aug. 27	Mills Lake Nursery, Markato	253	5.50
Aug. 28	Anthony McMullen Nursery, Wabasha	254	6.50
Aug. 28	Pioneer Nursery, New Ulm	255	6.50
Aug. 31	Lyon Co. Evergreen Nursery, Cottonwood	256	6.75

08.	Name and Town.	Cert. No.	Cash.
. 31	Sacred Heart Nursery, Sacred Heart	257	6.25
t. 1	C. J. Orton & Son, Marietta	258	6.50
t. 1	Madison Nursery, Madison	259	6.50
t. 14	Excelsior Nursery, Excelsior	260	1.15
t. 14	Brackett Nursery, Excelsior	261	1.15
t. 14	Old Fashioned Flower Garden, Excelsior	262	1.15
t. 14	Lyman Nursery, Excelsior	263	1.15
t. 14	L. L. May & Co., St. Paul	264	5.40
t. 14	Lakeland Nursery, St. Paul	265	5.40
t. 15	North Star Plant Farms, Cokato	266	3.00
t. 15	Wright County Nursery, Cokato	267	3.00
t. 15	Howard Lake & Victor Nurseries, Howard Lake	268	4.00
t. 15	Hennepin County Nursery, Eden Prairie	269	3.10
t. 15	Strand's Nursery, Taylors Falls	270	6.96
t. 15	Elliott & Redpath Nursery, Crystal Bay	271	1.00
			$214.91
dit, by money paid State Treasure			$214.91

CROWN GALL ON MINNESOTA RASPBERRIES.

The Minnesota law provides that the Nursery Inspector take cognizance not only of "dangerously injurious insects" in nurseries, but also of "contagious diseases." Crown Gall comes under the latter head.

This disease first attracted the attention of Experiment Station workers in 1892 in California. It is not our purpose to discuss "hairy root" which appears in connection with Crown Gall on the apple, nor, in fact, to touch upon the crown gall of the apple at all in this publication, beyond the statement that it is believed that apples infested with this disease do not thrive, do not bear good crops, and may succumb. This is contradicted by at least one of our local nurserymen, who claims that they do well in spite of its presence. It is possible that the hard crown gall is confused with the so-called "soft gall" in this connection. It might be said, however, that probably many planter has accepted trees infested with "hairy root" (a disease which is produced a large number of black, wiry rootlets in connection with gall-like swellings) not knowing, and the nurseryman sell them to him not knowing that such trees will remain stunted, in sp of the seemingly fine root growth. We propose to discuss here, v briefly, the danger which threatens our raspberries, since it is of t that complaints have been received.

The crown gall found upon apples cannot, as far as is known, easily transmitted to raspberries, blackberries, plums, cherries, etc. is believed, also, that the raspberry and blackberry cannot re transmit their peculiar form of crown gall to the apple. We know one Minnesota nurseryman who reared a good crop of apple roots o patch which had been plowed up three years before on account o crown gall on raspberries. The "soft form" of crown gall on plum cherry, peach, raspberry and blackberry, is highly contagious (this has been demonstrated in practice), and is evidently the same species on all five of these latter fruits. The most recent workers claim that this form of crown gall is of bacterial origin. It would appear too, that the reproductive form of the organism may remain alive on surface

Fig. 26. Three varieties of Minnesota raspberries affected with Crown Gall.

of gall or in the soil for some time, several years—just how long is not known.

We quote Dr. Hedgecock's summary of his recent work with this organism published in Bulletin No. 131, Bureau of Plant Industry, Aug. 17, 1908:

"The soft galls from the almond, apricot, blackberry, cherry, peach, plum, prune, and raspberry have been transferred easily to seedlings of the almond, apricot, peach, and raspberry; less readily to those of the blackberry, cherry, plum, prune, and pear; and with great difficulty to seedlings of the apple, chestnut, walnut, and rose.

"The soft galls of the apple, chestnut, walnut, rose, and pear, as a rule have not been transferred readily to any of the plants mentioned. Evidence has been obtained of a wide range of susceptibility in different varieties of the same plant. This has been noted in varieties of the apple, blackberry, cherry, chestnut, pear, and rose."

Upon the raspberry Crown Gall occurs as bunches near or at the crown (see Plate), but may appear on parts above the ground, and eventually weakens and kills the plant. Delaware has lost 40 per cent or more of her vines through Crown Gall, and the raising of berries there has consequently received a serious check. As evidence of the contagious nature of this disease it may be said that scientific and practical workers have demonstrated that healthy vines planted in sterilized soil, and bits of Crown Gall placed about them, develop the disease. It is evident, too, that rain could easily wash the germs or reproductive bodies on the surface of the galls to other plants. This, too, has been demonstrated in practice by the facts that plants found on a hillside, or in a hollow below infested plants, also contract the disease. An inspector finding diseased crowns on raspberry vines on the higher portions of a field can generally safely predict the occurrence of the disease lower down where the wash of the rains has brought the germ down from the higher ground, if sufficient time has elapsed to allow of growth of gall resulting from the contamination.

Crown Gall is apparently on the increase in Minnesota nurseries, and so destructive is it to vines, and so insidious in its method of spreading that we deem it necessary to call special attention to it at this time. The increase of this disease has been brought about largely by infested nurseries sending vines into widely separated regions. It is very evident that one nursery may infect an entire state or several states. Although undoubtedly existing here for a number of years, the first complaint reached us less than a year ago. In this case raspberries were suffering. We had a year before found this on

berries upon our experimental grounds, and as probably illus-g the contagious character of the disease, it may be said that our berries and the raspberries complained of by our correspondent from the same nursery. Our diagnosis in this particular was corroborated by Washington authorities in the Bureau of Plant try. A visit to this establishment last fall, at a time when the were being dug and placed in the cellar, disclosed the fact that l varieties of raspberries were affected. *Affected and apparent-lthy stock was being tied up in the same bundles.* The healthy g stock is what goes out to patrons, but that this carries the dis-with it is, we believe, shown by the facts above mentioned.

One Minnesota nurseryman writes us that the first time he noticed own galls was in the fall of 1906, and on Golden Queen Rasp-s. The raspberries in another nursery were badly affected five ago, and the owner "plowed the whole patch under" seeding lover for two years, and following with potatoes. He does not to plant raspberries there again as long as he can get other d.

n looking over the nursery legislation in the various states we at about two-thirds of the states which have nursery inspection specifically mention the presence of crown gall in a nursery as lifying, and that nearly all the states which do not mention it cally include it by inference as a "contagious disease."

artly at the request of the writer this subject was placed on the m of the Sixth Annual meeting of the National Association of ultural Inspectors, which convened in Chicago in December, and inspectors and representative nurserymen who were pres-ined in the discussion. There seemed to be a decided unanimity ion in treatment of Crown Gall on the part of the inspectors. *either refuse to grant a certificate where Crown Gall is found to sent, or grant it with the words "except raspberries and black-" on the certificate, or grant it only upon receipt of a written ent from the nurseryman that he will destroy and not offer e any vines grown in a block condemned by the inspector on ac-of the presence of this disease. If the nurseryman breaks his in this connection, and knowledge of the fact comes to the in-r, the certificate granted is revoked.*

rom the fact that the presence of Crown Gall disqualifies a nur-n in various states and from certain published statements re-g its injurious effects upon vines, it seems fair to conclude that disease calling for careful oversight on the part of nurserymen

and growers. The entomologist found it present this fall in two nurseries visited in October and has written a few practical growers to obtain their opinion regarding it. Mr. Thos. Redpath replies to our letter of inquiry as follows:

"Wayzata, October 23, 1908.

"Dear Sir:—Replying to your letter of October 21, would say that I have known Crown Gall to exist on raspberries for last seven or eight years. I have not lost the vines entirely, but am satisfied that their bearing qualities have been affected by the disease.

"I am certain that it spreads from plant to plant, but some varieties are more subject to it than others. I never saw it on the Marlboro, and have none on my place since ploughing up the Loudon, only I saw it on the plants bought this spring, but if you think it best, I will cut them out."

A letter from A. Brackett, Excelsior, dated Oct. 26, '08, reads as follows:

"It has been in this locality for 7 or 8 years to my knowledge.

"It will soon destroy the entire patch.

"I have not had any on the place where I now live, but there are some places that are badly affected by it. It spreads very fast. I think the cultivator spreads it."

Another observant nurseryman writes as follows:

"Replying to your recent circular letter, the first indications of crown gall on raspberries that we noticed was three years ago this fall when we were digging a block of Loudon raspberries. This sort had previously done exceptionally well with us, but since that time has appeared less hardy or weaker. Hence we discarded it for the King and Ironclad.

"As we have not up to the present time planted raspberries or blackberries on the same soil, we cannot say as to its effect in that respect.

"To the best of my knowledge, our blocks are very free from this disease at present and hence I cannot say as to its contagious character in that respect."

Mr. E. B. Miller of Station F, Minneapolis, writes that he has seen it for two or three years, perhaps longer, but did not know what it was; that vines have been dying for years, apparently, he says, from this cause.

Under date of October 27, 1908, E. F. Smith, Pathologist, in charge of Laboratory of Plant Pathology, U. S. Department of Agriculture, writes us as follows:

"Your letter of October 16 to Dr. Hedgcock has been referred to me for reply. There are not enough data in your letter to enable me to reply very satisfactorily, and it is quite possible in the present state of our knowledge of this disease that were I on the ground I might not even then be able to answer fully your inquiries. I should attribute the slight amount of crown-gall on plants grown in soil which gave a large amount the pre-

ous year either to the fact that they were more resistant varieties, or that e dry weather this year largely prevented infection. There is no possible ubt any more as to the cause of the ordinary crown-gall. Although Dr. ownsend and myself have not published any very lengthy disquisition on e subject, that is not because we have not worked lengthily on it, and in ie time we shall have out a bulletin. The appearance of the disease in a orse form in another part of the nursery on what you state to be similar nd of ground in plants transplanted from the infested ground the previous ar, I would explain as possibly due to the fact that the soil, while similar, not identical, but perhaps moister. Of course, if the plants were transanted from the infected land they would carry with them sufficient numer of the bacteria to explain the infections, and all that would be necesary would be right soil conditions, that is, enough moisture.

* * *

"I will say to you personally that we have reproduced the crown-gall hundreds of times with pure cultures of our bacteria. We have cultivated out the organism from galls thus produced, and have reinoculated the same many times, obtaining galls again, and from these galls we have again cultivated out the organism and reproduced the disease. We have made a good many cross-inoculations also from one plant to another, but this part of our work has not yet been completed. With susceptible plants and young cultures we have a number of times obtained a hundred per cent of infections and none on the checks."

The Minnesota inspector feels that he must, for the good of the nurserymen, as well as for their patrons, fall in line with the inspectors of other states, and follow their example. He feels that there is occasion for special effort in preventing the increase of crown gall in Minnesota. He feels sure, further, that all nurserymen will heartily co-operate, not only to protect their patrons, but themselves as well. What, then, can they do to aid in stamping out this disease? They (and citizens generally) can refuse to buy any raspberries from a nursery known to have crown gall. They should refrain for several years, from using ground wherein affected stock has been found for such crops as raspberries, blackberries, plums, or cherries, keeping it free for some time of all brambles wild and cultivated. But scientific and practical workers, agree that apples cannot readily contract the disease from the above fruits, hence we believe apples might be planted with safety in such ground. Affected vines should be destroyed by burning as soon as found and where such affected vines are numerous, the stock in the entire block where they occur should be burned for reasons given above. Finally, nurserymen can follow faithfully and generously the suggestions of the inspector or his representative, even though the pocket book is for a time affected. Treatment, be it said, must be preventive rather than curative.

To further emphasize the need of special effort toward eradicating this pest, the entomologist, in November, 1908, sent the following brief circular to nurserymen:

TO THE NURSERYMEN OF MINNESOTA.

We are endeavoring to prevent the spread of Crown Gall among raspberries in this state. We know that you will co-operate with us in keeping it from your field and from your cellars, and from any shipment which you make of raspberry vines, or any other vine upon which there is Crown Gall. Such vines should be destroyed in the field, and not brought into the root house, nor allowed to stand in the field. When done up with a bundle of unaffected roots, the diseased root may, if the spores of the disease are at the right stage, infest the plants which you propose shipping in the spring. I quote a paragraph from the New York inspector to the nurseries of that state, showing how important that inspector regards this matter:

"There are in the state of New York about five hundred nurseries, embracing about ten thousand acres of land. These nurseries have 37,535,000 fruit trees, 16,000,000 ornamental trees, 4,750,000 currants, 15,500,000 grape vines. The nurserymen expect to receive a certificate of inspection from this department previous to the fall digging season. The inspection authorities of several other states are attempting to keep out of their states trees that are infected with wooly aphis, and plants that are infected by galls on the roots. At the time of our summer inspection it is difficult to estimate the number of trees and plants the roots of which are affected with galls. I therefore request that the nurserymen give close attention to the trees at digging time to see that all trees and plants affected by galls are destroyed or kept out of shipments. Supplemental inspection of nurseries and packing grounds will be carried on under the direction of the department at shipping and other times when it is possible to do so. We understand that trees that are infested with root galls are regarded by leading nurserymen as unmerchantable, but whether this is so in all cases or not, they should not be permitted to enter shipments for the reason that insects and diseases will thereby be spread. The inspectors of the department will be at the service of the nurserymen for the inspection of their trees and requests for inspection should be sent to this office."

As intimated above, I am quite sure you will do all you can to stamp out this destructive disease.

TWO YEARS' WORK IN SPRAYING AND SUGGESTIONS TO THOSE WHO CONTEMPLATE SPRAYING; REMEDIES FOR PESTS OF THE ORCHARD AND GARDEN.

Bordeaux Mixture plus arsenate of lead comes as near being a "cure-all" as we can expect in any single compound. One need not expect absolute immunity the first year of the treatment, especially after a number of years of neglect in this regard, but intelligent and faithful spraying for two or more seasons will certainly bring excellent results in the majority of cases.

In this connection the reader is asked to examine the article on spraying for the Plum Curculio, p. 83, which represents careful investigations in 1907 and 1908, and striking results.

Primarily this work was intended to demonstrate the value of spraying to the horticulturist and nurseryman, and at the same time we have been making a comparison between the merits of liquid and dust sprays. The accompanying picture, Fig. 27, is a most convincing proof of the value of spraying fruit, and Fig. 28 shows what may be accomplished by judicious spraying of a tree which is naturally so diseased as to be almost worthless.

Two experiments conducted by this department on the Station grounds in 1907 may be taken as further proof of the efficacy of spraying. A block of plum trees was sprayed for the Plum Curculio, six pounds of arsenate of lead in every hundred gallons of water being the arsenical agent employed. On trees sprayed twice with this solution sixty-two per cent of the plums were marketable, and on trees sprayed three times, seventy-seven per cent of the plums were fit for market, while on the check or unsprayed trees only fifty-three per cent were worthy of being offered for sale.

Another convincing argument is offered by our experiment in the Station apple orchard, where liquid Bordeaux and Paris green was used, resulting in the treated trees giving us eighty-one per cent of marketable apples, compared with thirty-six per cent marketable fruit

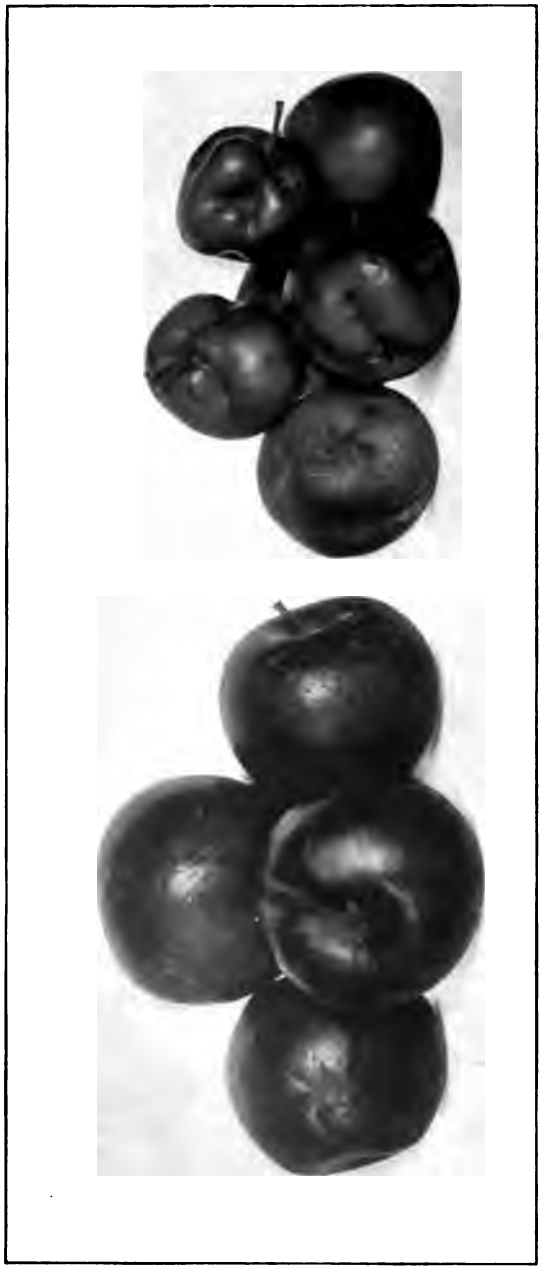


Fig. 27. Minnesota Wealthy Apples on left from trees sprayed three times with Bordeax solution and Paris green, the orchard having received a thorough treatment the previous year. The owner was offered $4.00 per barrel for all of his Wealthys. Apples on right from an unsprayed orchard.

untreated trees. This experiment was conducted against Codling , Plum Curculio, which in Minnesota is a worse pest on apples the previously named insect, and against Scab.

A member of the State Horticultural Society has intimated that the fruit growers of Minnesota most need at this time is a short ed article describing the most efficient all round compound for use, and how to make the same simply and inexpensively in small ities, and the proper times to apply it.

Fig. 28. Two Martha Crabs in the same nursery row, the one on left sprayed several with Bordeaux solution; the right-hand tree receiving no treatment.

It is evident that while we may have something approaching a all" (Bordeaux mixture and Paris green or arsenate of lead, a ined fungicide and insecticide, comes the nearest to this), it can- o everything, and in a treatise dealing with this it would be mani- unfair to the subject not to mention various other compounds

...s the fruit grower a farmer may be called upon to occasionally

...irst of all the fruit raiser and the farmer must be provided with ...p suitable for his needs with pumps, hose and other apparatus ...ited to the special work in hand, the nature of the work determin...ng the character of the outfit in each case. A few trees, bushes or ...s with possibly a hen-house or white wash occasionally, evidently ... on a simple and inexpensive scale. While acreage in orchard or ...rden calls for more elaborate machinery which may cost anywhere ...m $15 to $100 or over and the cost of which may be profitably ...ared by a few neighbors.

The following is a list of many of the firms who make spray ...mps and spraying machinery of all sorts. Any of these parties will ...ubtless send descriptive catalogues and price lists to any applicant. ...me of these first are represented by agents in a number of towns in Minnesota.

...E. C. Brown & Co., Rochester, N. Y.; Dust Sprayer Mfg. Co., ...0 Broadway, Kansas City, Mo.; Deming Co., Salem, Ohio; W. & B. ...Douglas, Middletown, Conn.; Field Force Pump Co., Elmira, N. Y.; ...Friend Mfg. Co., Gasport, N. Y.; J. F. Gaylord, Catskill, N. Y.; ...Gould's Mfg. Co., Seneca Falls, N. Y.; Hardie Spray Pump Mfg. Co., ...Detroit, Mich.; H. W. Henry, LaPorte, Ind.; Hills Dust Spray Mfg. ...Co., McPall, Ohio; Leggett & Bro., New York City; J. J. Kiser, Stan...wood, Mo.; Morrill & Morley, Benton Harbor, Mich.; F. E. Myers & ...Bro., Ashland, Ohio; Niagara Spraying Co., Middleport, N. Y.; ...Peerless Loop Sprayer Co., North East, Pa.; Rochester Machine Tool ...Works, Ltd., Rochester, N. Y.; Ripley Hardware Co., Grafton, Ill.; ...D. H. Smith & Co., Utica, N. Y.; Spramotor Co., London, Ont., and ...Buffalo, N. Y.; Wm. Stahl, Quincy, Ill.; Wallace Machinery Co., ...Champaign, Ill.; R. B. Williamson, Clifton Springs, N. Y.; Hurst Mfg. ...Co., Canton, Ohio.

The fruit grower or farmer having made up his mind exactly what he needs, should get the best the market offers when consistent with what he can afford. Further, he should purchase his outfit and supplies early enough to be ready for the work of spring and early summer.

1. **Bordeaux Mixture,** to which Paris Green or arsenate of lead has been added, making a combined fungicide and insecticide, is regarded as intimated above, as the *most serviceable, all round material for general use on bearing fruit trees,* as well as berry bushes upon which the fruit is not set, the lime of the Bordeaux preventing the ...s green from burning the foliage. Bordeaux mixture, however,

if used too strong, will cause a russeting of fruit and a burning of the leaf. Therefore, from observations made at this station, which are corroborated by the experience of others, we have discarded the stronger solutions, and find the so-called 3-3-50 formula effective and safe. This is made as follows: Dissolve three pounds of blue stone (copper sulphate) in a known number of gallons of water, ten to twenty as the case may be, in a wooden or earthern vessel, *never in metal.* When dissolved add enough water to make twenty-five gallons. In another receptacle slake three pounds of quick lime in the same way, adding to that also sufficient water to make twenty-five gallons. These two solutions are to be kept separate, covered to prevent evaporation. When wanted for use, pour together into the receptacle from which the pump draws its supply, equal parts of each, *stirring the lime solution thoroughly before doing so,* in order that the lime which has settled may be in suspension. Do not pour the two solutions together before diluting. One must be sure that this solution is not acid. Two simple tests may be resorted to to determine this, namely: (1) Hold a clean, steel knife blade in the solution a minute or two, if it becomes copper coated, more lime should be used. (2) If a little of the solution be poured into a shallow dish and one gently blows across the surface, a thin film should form; if it does not, add more lime.

The solution should be strained through a copper or brass strainer, or coarse cloth when being placed in the pail, barrel, or tank which is to be used, in order to exclude large particles which might clog the pump. Further, after using the pump for this mixture it should be thoroughly cleansed by having water forced through it. This, in fact, should be done after every use of the pump, hose and nozzles. A combined Bordeaux and Paris green or arsenate of lead may be bought ready prepared of some firms selling spraying machinery. This comes in a dry or paste form and is added to water when it is ready for use.

This compound, Bordeaux mixture alone, remains for a long time on fruit and leaf and twig; it prevents in a large measure attack by *scab, mildew* and other fungous troubles, but it is not a cure. In other words, it should be placed upon leaf or fruit before it is attacked, and a sufficient number of applications should be given (see below) to keep the same well coated with the mixture until within a few weeks of gathering. Now, if Paris green is added to this mixture at the rate of three pounds for every 100 gallons, or arsenate of lead (disparene) at three or four times that strength, not only will the spores of most fungous diseases, with which it comes in contact, be killed, but all insects as well, which bite leaf, or twig, or fruit, such as plum cur-

culio, codling moth, tent caterpillar, canker worms, etc. We much prefer arsenate of lead to Paris green. If Paris green is used it should be of good quality. Insist upon Paris green being sold you in sealed packages; do not purchase an article which looks pale green. If an eighth of a teaspoonful of Paris green is placed in a wine glass full of strong ammonia, and stirred with a stick sharpened to reach the lowest point of the liquid, it turns the latter blue, and there should be little or no sediment in the glass after stirring. The presence of sediment indicates adulteration. Minnesota would do well to enact laws preventing the sale of adulterated Paris green.

Arsenical sprays (Paris green or arsenate of lead) being internal poisons, should never be used against sucking insects, such as plant lice, scale insects, squash bugs, etc. Use soapy solutions, or kerosene emulsion for lice; crude petroleum or lime-sulphur solution on dormant trees for scale insects.

Paris green, when added to Bordeaux mixture, can be safely used in greater proportion than one pound to one hundred gallons, and we believe, with profit. Inasmuch as it is the minute particles of Paris green adhering to leaf and fruit which the insect eats with fatal results, it follows that the more of such particles there are to a square inch of surface the greater the chance of a pest, the apple worm, for instance, getting the poison before it gets out of danger, inside the apple for example. It would be unsafe for a fruit grower to use, on his fruit trees, Paris green and water alone, stronger than one pound to every one hundred and fifty gallons, but if lime were added the acid burning qualities of the fatal arsenic in this compound would be neutralized in proportion to the amount of lime used, and might be entirely done away with.

The 3-3-50 Bordeaux mixture does this, and we have personally used one pound of Paris green in every fifty gallons of this mixture as a spray upon tender foliage of apple and plum as well as upon young tomatoes in the greenhouse. We have preferred, however, in this report, to conform to the more conservative views of some of our fruit growers, and have advised one pound of Paris green in every one hundred gallons of the above mixture. *We strongly urge the use of arsenate of lead in preference to Paris green.*

In this connection it is interesting to note the remarks of Dr. Marlatt in Farmers' Bulletin No. 127, issued by the U. S. Department of Agriculture, April 14, 1908, in which he states (p. 11) that "If it be desirable to apply a fungicide at the same time, as on the apple for the Codling Moth and the Apple Scab Fungus, the Bordeaux mixture

ıy be used instead of water, adding the arsenical to it at the same :e per gallon as when water is used. The lime in this fungicide utralizes any excess of free arsenic, and makes it an excellent med- n for the arsenic, as it removes liability of scalding the foliage, and *rmits an application of the arsenical, if necessary, eight or ten times strong as it could be employed with water alone.*" The italics are : writer's. However, as stated above, we strongly urge the use of : always safe arsenate of lead in preference to Paris green.

2. **Arsenate of Lead (Disparene)** sells for about the same ice as Paris green, remains longer on leaf and fruit, and cannot burn e foliage. We regard it as far preferable to Paris green for the rea- ns stated. Fig. 30 illustates apple leaves from a tree sprayed with ordeaux and Paris green in 1908, three weeks and three days after)raying, during which period there was much rain. Although the Bordeaux shows on the leaf, chemical analysis gave no arsenic, where- s, Fig. 31 represents plum leaves, sprayed in 1908 with Bordeaux nixture and arsenate of lead (three pounds to fifty gallons), the photo)eing taken after four weeks' of exposure to rain and varying weather. In this case not only does the compound show on leaf very clearly, but upon chemical analysis a trace of arsenic was found. We have the highest respect for arsenate of lead, both as regards its "staying qualities," and also its freedom from the injurious burning qualities which make Paris green dangerous to foliage unless carefully handled. In this connection it is to be noted that while arsenate of lead costs about the same as Paris green, it is used from three to six times as strong, making an application more expensive than a similar one with Paris green. Yet it lasts on the foliage and fruit so much longer than the latter that it calls for fewer sprayings, and would seem to be in the end, fully as economical. Arsenate of lead and other spraying compounds can be purchased in quantities at the leading wholesale drug houses.

3. **Paris Green:** See above. In water for use on fruit trees should be employed at the rate of one pound in every one hundred and fifty gallons. This should be kept continually stirred, otherwise the Paris green sinks to the bottom of the liquid. A pound of quick lime for every ten gallons of the solution will do much to overcome the burning propensity of this compound.

4. **Ivory Soap:** Excellent for plant lice in the flower garden. A five-cent cake cut up and dissolved in six or seven gallons of hot water is excellent against lice on golden glow, sweet peas, roses, etc.

5. **Kerosene Emulsion (Hubbard Formula):** Dissolve one-half pound of any hard soap in one gallon of water by boiling. Take from fire while still boiling. Add two gallons of a cheap grade of kerosene, and churn with a spray pump until it becomes soft and creamy in texture. This is the stock solution. For plant lice use one part of stock solution to eight or ten of water. A serious objection to this in the hands of many is the fact that after the mixture has stood a while, even when being used, free oil rises to the surface, and this, if applied to a tree, will generally cause a burning of the foliage. A soap solution is a safer agent.

6. **Sulphite of Potash (Liver of Sulphur)** can be purchased at most drug stores. Dissolve one-half to one ounce in one gallon of water and use for mildew on rose, gooseberry, etc. Discolors white paint. See also No. 9.

7. **Resin Soap:** Good for plant lice; also used as a "sticker," being added to spraying solutions to make them stick to glossy surfaces. Dissolve a pound of caustic soda in one and one-half gallons of water. Add two pounds of resin and one pound of tallow, and dissolve by a moderate degree of heat. Add water enough to make three gallons. Add this to fifty gallons of spraying mixture.

8. **Winter Sprays:** Lime-sulphur solution, crude petroleum, etc. Excellent for scale insects.

9. **Ammoniacal Copper Carbonate:** An excellent fungicide, useful in cases of tomato blight, also against mildews on roses, rust, etc. Pour three pints of ammonia (about 25 per cent) into a gallon of water in an earthern or wooden receptacle. Add five ounces of copper carbonate and stir. If it all dissolves, add more, until a small amount remains in the liquid. The resulting compound is blue; it should be kept in corked jugs, and be used within a few weeks. The above stock compound should be diluted with sufficient water to make fifty gallons.

Apple. **Codling Moth, Plum Curculio, Tent Caterpillar, Canker Worms, (all insects which eat twig, leaf or fruit), Scab, Mildew.** Use No. 1 just before flower buds open, again after all bloom has fallen. Apply two or three subsequent sprayings at intervals of two weeks. More frequent applications are useful. Sprayings should be so timed that the young leaves receive an application upon their first appearance, when they are about the size of squirrels' ears. Plum curculio can also be jarred off the trees on sheets below. Jar every three days after fruit has formed for three or four weeks. **Lice or Aphids:** In the case of nursery stock and small trees, the branches may be bent over and the infested tips "swashed" thoroughly in a pan of No. 4, No. 5 or No. 7, or in a mixture of soap-suds and tobacco.

Plum. **Plum Curculio, Caterpillars, etc., and all insects which eat twig, leaf or fruit. Most fungous troubles.** No. 1 as under Apple. **Lice or Aphids:** See under Apple. Curled leaves concealing lice may be picked off and destroyed.

Raspberry. **Anthracnose:** This disease can be kept within bounds by cutting out infested canes, and early spraying with No. 1, with or without the Paris green. Repeat at intervals of about ten days, avoiding spraying when bushes are in bloom. Stop spraying some time before the fruit begins to ripen. Where vines are badly infested they should be destroyed.

Currant and Gooseberry. **Currant and Gooseberry Worm:** Use No. 2, one pound in ten gallons of water, or No. 3, one pound in twenty-five pounds of air slaked lime, while fruit is small. Afterwards hellebore as dry dust when leaves are wet with dew, or one ounce in one gallon water sprayed or thrown on with small broom. The worms may begin their work on the inside of the bushes, and are likely to be overlooked. No. 1 could be used in place of No. 2 or No. 3.

Strawberry. **Rust, Flea Beetle, Leaf Roller:** No. 1 before flowering, and once immediately after bloom has fallen. Two or more applications after harvesting the fruit.

Melons. **Blight, Beetles, striped and otherwise:** No. 1 first application when about four or five leaves, then keep foliage well covered by spraying with No. 1 every eight or ten days. Spray under side of leaves as far as possible. Pick off diseased leaves as fast as they appear. Do not spray during the harvesting of the crop. Vines should be collected and burned immediately after crop has been gathered. **Lice.** If patch is small, spray under side of leaves with No. 4 or No. 5. Destroy all old vines.

Cucumbers and Squashes. **Beetles:** Same as under Melons, or dust plants with Paris green one pound, mixed with fifty pounds of cheap flour or lime. Plant an excess of seed. **True Squash Bug:** Hand picking early in morning; planting an excess of seed; where plants are not too numerous protection by coverings until they are beyond injury. Hand picking of large yellow eggs. Destroy all vines after gathering crop. This bug, it is claimed, will attack squashes (or pumpkins) before it does cucumbers or melons, therefore, raisers have protected their melons by planting squashes and pumpkins near them as a catch crop.

Tomatoes. **Cut Worms and Wire Worms:** Use paper about stem, making a collar which extends into the ground two inches, and four inches above ground, tin cans with ends burned off, in fact anything which will make a protective collar for a time. Poison bran mash with Paris green, sweeten and place these baits about, not too near the plants. Careful and frequent cultivation, killing worms when found; searching in ground near cut plants for worms, and killing same. **Blights (and cut worms, flea beetle, etc.)** No. 1 when plants are in cold frame or green house, and spray under side of leaves as far as possible. Repeat three or four times after plants are set out, at intervals of eight or ten days, spraying the ground about the plant as well as the plant. Destroy

diseased leaves as soon as they appear. In bad cases remove affected plants and destroy them by burning. Some blights are carried from plant to plant by insects. Keeping insect pests in check, therefore, means less blight. Careful pruning, staking and cultivation help; rotation of crops also. No. 9 is an excellent fungicide for many blight diseases on tomatoes.

Potatoes. **Potato "Bugs." Blight:** Use No. 1 for the first time when plants have about six to eight leaves, and continue for several sprayings at intervals of ten days or two weeks. Later sprayings may be given at any time if "bugs" are active.

Cabbage and Cauliflower. **Green Cabbage "Worm," and all leaf-eating caterpillars, Flea Beetles, etc.** Paris green or arsenate of lead and water during the season as frequently as occasion demands on cabbage. Cauliflower should not be sprayed after heads begin to form. Use dry hellebore, which is harmless to man, if cauliflower heads are being eaten by insects. Cabbages can be sprayed with any arsenical up to within a few weeks of gathering. They are not easily injured by Paris green, and some growers use it as strong as three pounds in fifty gallons of water. A quart of soft soap, or eight quarts of very strong soap-suds should be used in every fifty gallons, to insure the liquid's spreading over the leaf. **Root Maggot:** Steep two ounces of white hellebore in one quart of water for an hour, dilute with water to make one gallon of the decoction. Apply with sprinkling can a few days after plants are set out; five days later apply again, and a third application five days after the second. Apply seven or eight times more at weekly intervals.

Rose. **Lice:** Watch bushes carefully and use No. 4 whenever the pests are seen. Spray forcibly. **Rose Beetles, Rose Chafers:** jarring on to cloth beneath bush early in morning, then collect and destroy. White hellebore dry when leaves are moist- **Leaf-cutting Bee:** Dissolve one-half pound of whale oil soap in four gallons of water, and sprinkle leaves when plants are not in bloom; while foliage is still wet with this solution dust with powdered sulphur. **Mildew:** Use No. 6 or No. 9 at the very first appearance, and repeat whenever necessary. No. 6 stains white paint. Dusting powdered sulphur on leaves when they are damp is good. **Black Spot:** Use No. 9 every week.

Controlling the Codling Moth with One, or at Most, Two Sprayings: Prof. Ball of Utah, and other workers on the Pacific Coast have revolutionized spraying for the Codling Moth where this insect alone is to be combated. They find that by one, or, at most, two sprayings, judiciously timed and properly applied, almost the entire crop of fruit can be saved.

Ball's method is based primarily on two important facts. He claims that wherever upon the apple the eggs of the first brood are laid, a great majority of the young worms (over $\frac{2}{3}$) coming therefrom crawl to the calyx and enter there. Secondly, and a condition which has not been taken into consideration hitherto by entomologists, is the fact that in a young apple, immediately after the petals fall, there are two cavities at the calyx end, the stamen "bars" (Ball) roofing the

lower of the two cavities, see Fig. 29, b and b1. The young larva enters the apple by eating through the floor of the lower cavity. Ball's idea was to get the poison lodged, in sufficient quantity in the lower cavity where it would do some good. To accomplish this he sprayed from above, while the apples were still erect, Fig. 29, a. But for a few days after the petals fall, these stamen "bars" are so tightly pressed together as to make it very difficult for the liquid to penetrate to the lower cavity. By waiting a week or ten days, even though the calyx lobes are closing at that time, these bars have shrunk, Fig. 29, c and c1, enabling a careful workman to place a big dose of poison in

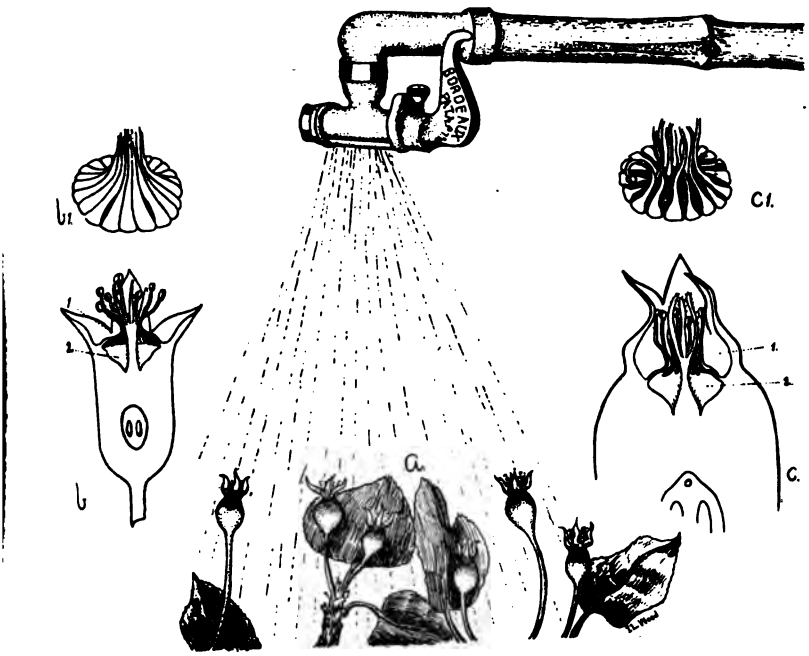


Fig. 29. a, after Slingerland; b, b1, c, c1, after Ball.

the lower chamber, where it is needed. The nozzle should be held above the apples, and made to give, not a mist, but a forcible and substantial spray, directly down upon the fruit. Later than this, however, spraying with these principles in view would be of little avail because the calyx lobes are almost completely closed. Ball's work shows that enough poison is retained from two early sprayings to kill an average of ninety per cent of the worms of the first brood and seventy-four per cent of the second brood. To accomplish good results the spray must be a forceful one used abundantly, *and from above the fruit.*

We insert this here, a very brief summary of a most excellent and exhaustive report made by Prof. Ball at the Nineteenth Annual Meeting of the Association of Economic Entomologists, held in New York City in December, 1906, since it is a new and radical departure from previous work in spraying for the Codling Moth, and gives spraying an entirely different aspect. Mr. Ball's findings are to be regarded as of great practical value to fruit growers who have only the Codling Moth evil to contend with. In this state where the Plum Curculio is a greater foe to the apple than the above named insect, we have to resort to a different and more expensive treatment. See article on "Spraying for the Plum Curculio."

Fig. 30. Apple leaves (sprayed with Bordeaux and Paris green) three weeks and three days after application. Bordeaux still showing but no trace of arsenic upon chemical analysis. Original.

Dust vs. Liquid Sprays.

During both 1907 and 1908 most careful consideration has been given to the comparative merits of liquid and dust sprays for use in the orchard. These tests were undertaken without prejudice in either direction. The north portion of the Russian Orchard at the Experiment Station, was treated five times with liquid Bordeaux and Paris green, using eight ounces of the latter in every fifty gallons of Bordeaux. The middle portion of the orchard was left unsprayed as a check, and sixty trees on the south end were given a treatment with

y Bordeaux and Paris green (General Formula XX), at the same tes upon which the others were treated. The dust sprayed trees rther were given one extra treatment on August 13th. The total unt of the apples in the block treated with liquid Bordeaux gave ;hty-one per cent marketable and nineteen per cent unmarketable, ıile the dust sprayed trees showed seventy per cent marketable as

Fig. 31. Plum leaves sprayed with Bordeaux and arsenate of lead (3 lbs. to 50 gals.) after four weeks' exposure to weather. Chemical analysis gave trace of arsenic.

against thirty per cent unmarketable. In other words, there were sixty-two per cent more marketable apples than unmarketable in the iquid sprayed lot, and only forty per cent more marketable than unnarketable in the dust sprayed. These counts were all made on Duchess trees. Another block of nine different trees sprayed as above vith dust, showed only forty-three per cent of marketable apples,

while fifty-seven per cent of the fruit was not fit for market. In other words, there were more unmarketable than marketable apples. The causes of the injury which determined the above counts were scab, codling moth and curculio.

We feel compelled to say from our work of 1907, which was fully corroborated in 1908, that where water is abundant, and the ground level, liquid Bordeaux, to which arsenate of lead has been added, is far preferable to any spray applied as a dust. There is no question but that a proper use of dust spray gives good results, but these results are so dependent upon the weather, time of spraying and other conditions, that the disadvantages of its use are decidedly against it.

SPRAYING FOR THE PLUM CURCULIO.

The question as to the feasibility of using Bordeaux mixture and Arsenate of Lead against the various fungous diseases and the Plum Curculio, attacking apple and plum, was assigned as an experiment for the years 1907 and 1908, to Mr. A. G. Ruggles of this Division. His report on this work follows:

Ever since spraying has been recognized as a source of protection against injurious insects, more or less attention has been given to spraying for Curculio. In the East many fruit growers today feel confident that they can control this pest of the plum with

Fig. 32. Curculio catcher used in jarring trees. After Slingerland.

an arsenical spray, while others still adhere to the old method of jarring the trees and catching and destroying the beetles. See Fig. 32.

As all Minnesota fruit growers know, one of the greatest drawbacks to successful plum growing is the injury caused by the Plum Curculio. Often we have been told that "the plums set well and then all drop off before time for picking." Upon examination of these fallen plums 90% at least were found with the Curculio mark upon them. See Fig. 33.

Beside plums, apples are very badly attacked by this insect in Minnesota, and without doubt it is, in many sections, the chief enemy of the apple. When the fruit trees become large, and are placed so closely together, as they are recommended to be in this state, the use of the Curculio catcher is often a more laborious method of attack than in eastern and southern orchards.

More or less successful spraying experiments have been carried on by the Cornell Experiment Station against the Plum Curculio on plums, while other stations such as Missouri and Illinois, have

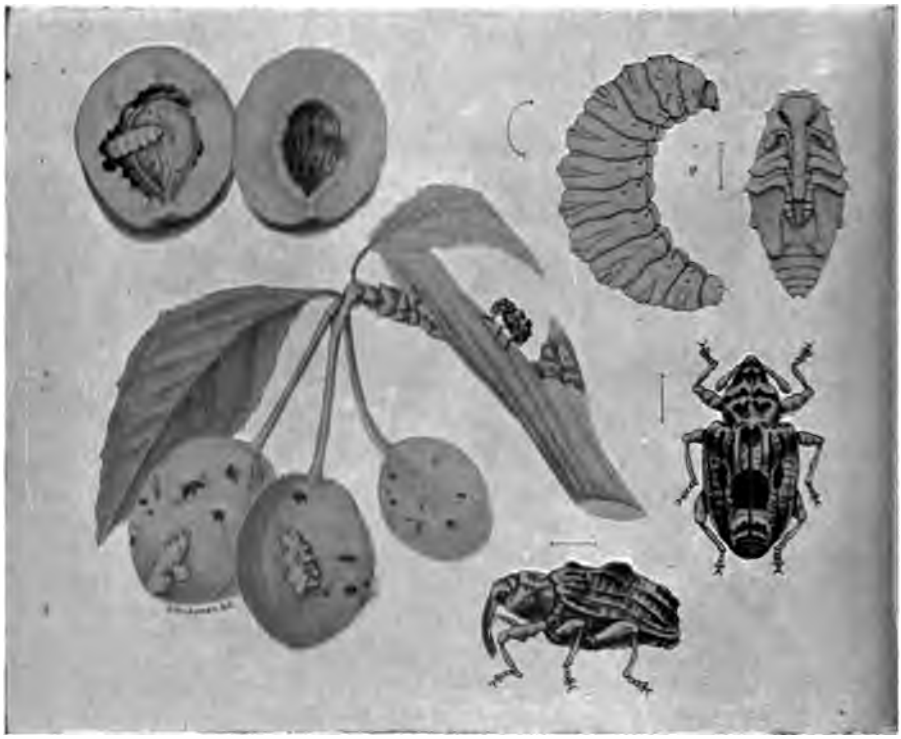


Fig. 83. Plum Curculio, adult and early stages; plums showing characteristic markings, with gum exudation. After Lugger.

carried on similar experiments against this insect on apples. In the interest of Minnesota fruit growers, spraying experiments against the Plum Curculio on plums were begun in 1907, and have been carried on through two seasons. These experiments have been conducted in the plum orchard of the Experiment Station, the use of which was kindly loaned for the purpose by the Horticul-

tural Division. Acknowledgments are also due to Messrs. O. F. Brand & Son of Faribault, and F. J. Butterfield of Long Lake for courtesies extended to the Entomological Division in allowing the use of their orchards for spraying experiments. Unfortunately weather conditions in one case, and lateness in starting in the other prevented any definite results from being obtained upon the plums in those localities. The data upon which the following suggestions are given were all obtained from work in the Experiment Station orchard.

The plum trees used in the experiment varied in age from five to ten years, the average tree being capable of bearing a bushel and a half of plums. They were of such varieties as Surprise, Wyant, Cheney, De Sota, Compass-cherry, etc. Although at the beginning of each season sixty or more trees were in the experiment, fruit set well only on some twenty-five trees.

Life History: The adult Plum Curculio, see Fig. 33, is a Snout Beetle nearly ¼ of an inch in length. The female beetle inserts her eggs beneath the skin of the fruit, and then turning around, makes the characteristic crescent shaped mark on one side of the egg, as seen in Fig. 33. From the egg hatches a little grub, which feeds on the fruit, eventually causing it to drop. When the grub is full grown it leaves the plum and enters the ground, soon changing into a pupa. Late in the season the pupa changes into the beetle, which passes the winter in protected places.

In 1908 the adult beetles were not found until May 30th, although observations were begun as early as May 1st. After their first appearance they were observed up to July 12th. It is possible that they were present in small numbers several days before May 30th, so that the actual Curculio season extended over a period of six or seven weeks.

In studying the habits of this insect one finds that in the spring it feeds for a time upon the leaves and the young fruit. The theory is, therefore, that if the leaves and young fruit are covered with a poison spray during the time the Curculio is at work, many beetles will be killed thereby. Plum leaves are very susceptible to burning from Paris green, but we find that arsenate of lead, however strong the mixture may be used, has no injurious effect upon the foliage, and at the same time sticks much better than Paris green. Consequently our experiments were carried on entirely with arsenate of lead, or a combination of arsenate of lead and Bordeaux mixture. Fig. 34 shows how well arsenate of lead sticks. The tree from

which this leaf was taken had been sprayed over four weeks previous to the taking of the photograph, and during this period the rainfall had been very heavy. At the time the picture was made three leaves were examined and analyzed by the Chemical Division of the Experiment Station, and traces of arsenic were still found. In this connection it is interesting to note that in another experiment where Paris green was used, handfuls of leaves were examined, and not a trace of arsenic was found.

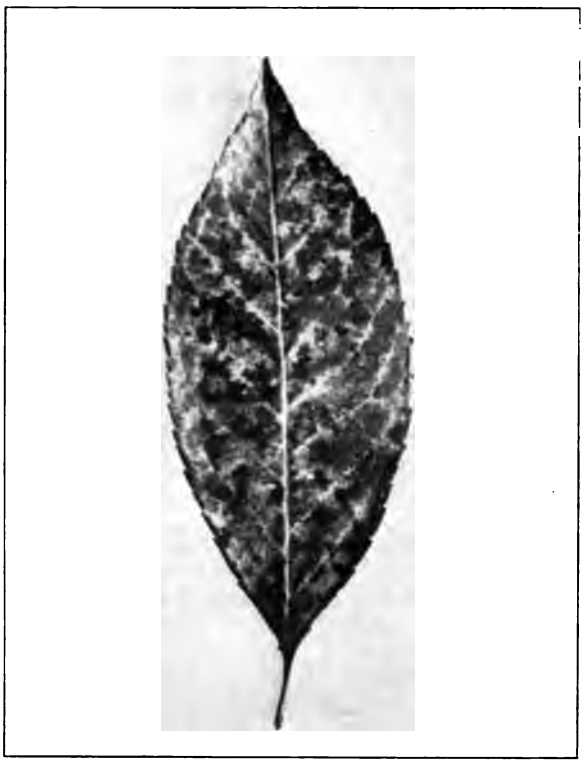


Fig. 31. Plum leaf showing adhesive qualities of arsenate of lead. Original.

The season of 1907 arsenate of lead at the rate of three pounds to fifty gallons of water was used. The first spraying was given just as the buds were bursting, namely, May 29th; the second spraying was done on June 17th, after the blossoms had fallen and young plums were the size of small peas. The third spraying was on June 24th.

Number of Sprayings.	Dates Sprayed.	Results.
None (check trees)		53% Marketable
2 Sprayings	June 17 and June 24	62% Marketable
3 Sprayings	May 29, June 17 and June 24	77% Marketable

The common Sclerotinia rot of the plum was so destructive in 1907, that in 1908 it was decided to use a fungicide with the arsenate of lead. Consequently, Bordeaux mixture (3 lbs. copper sulphate, 4 lbs. lime, 50 gals. water) plus three pounds of arsenate of lead was used.

The spring of 1908 started in very early, and the buds began to swell, some fruit buds showing white by the last of April, and because of this the first spraying was done as early as May 2nd. A cold period following this, the second spraying was delayed until May 27th. The trees were sprayed the third time on June 4th. The results are as follows:

Number of Sprayings.	When Sprayed.	Percentage of marketable fruit.
Unsprayed		40%
2 Sprayings	May 2, May 27	62%
2 Sprayings	May 27, June 4	74%
3 Sprayings	May 2, May 27, June 4	86.4%

In the comparison of these tables it is interesting to observe that the first spraying in both years gives results in favor of the early spraying. The result in 1908 is difficult to explain because the Curculios were not active to any extent until after May 30th, and yet this first spraying was given on May 2nd, a period of at least three weeks intervening before the Curculio began to work. The only reasonable explanation seems to be that the arsenic from the first spraying clung to the buds so that it was effective when the Curculios made their appearance.

In testing for Curculios it was very interesting to note the proportion of beetles found on the sprayed and unsprayed trees. For instance: On June 10th, jarring one unsprayed tree we obtained eight Curculios, while upon jarring three sprayed trees none were obtained. On July 2nd upon jarring three unsprayed trees three Curculios were found, and from the same number of sprayed trees none were found.

From July 2nd to July 12th, trees were shaken every day, and not a Curculio was obtained from a sprayed tree, although at least one a day was taken from a check tree.

In 1907 the plum crop at the Experiment Station was practically a failure, while in 1908, although below normal, it was much better than in the previous year. The results for 1908 are, therefore, more reliable for basing conclusions upon.

On the basis of a normal crop of 50,000 bushels of plums in Minnesota, or say $100,000 worth, if every fruit grower would spray, instead of there being only forty per cent of marketable fruit. there would be, to be conservative, twice that, or 100,000 bushels, an addition of $100,000 more to be divided among the fruit growers

Fig. 35. Details of injury to apples: *a*, egg punctures with larvae living in the pulp and the punctures beginning to decay; *b*, *c*, *d*, egg punctures beginning to heal, as eggs never hatched; *f*, badly stung portions of an apple; *e*, egg puncture nearly healed; *g*, scar in a depression.—Stedman.

of the state. It must be remembered in this connection that the Bordeaux mixture reduced the loss from Plum Rot and other fungous diseases.

Cost of Spraying: From careful data collected, we find that the cost of the three sprayings on such plum trees as were used in this experiment, is between ten and fifteen cents per tree. If a tree bore only a bushel of plums the extra quality of the fruit, as well as the lessening of the dead loss from fallen fruit, due to spraying, would more than repay for the fifteen cent outlay.

Cost of Jarring: The cost of spraying is insignificant in comparison with the cost of jarring. During the first part of the Curculio season the trees should be jarred at least every other day for the first three weeks, and after that every three or four days for a week. This entails an enormous expense of time and labor, while in spraying, the work of protection is all done in, at the most, three applications of the spray.

Spraying Apparatus: An ordinary barrel pump, with a Bordeaux nozzle was used in these experiments. Possibly more striking results would have been obtained if other nozzles, which experience has shown are to be preferred, had been used. The writer hopes to carry the work further another season, experimenting with such nozzles as the Vermorel and Mistry.

Other Methods of Control: The destruction of windfalls, either by means of cultivation during the latter part of July and August, or by turning hogs into the orchard during this period, will control this insect. Chickens being allowed free run in a plum orchard will also keep it down to a large extent.

A Co-operative Experiment: In one co-operative experiment the Grasselli Bordeaux Arsenate of Lead Paste was used on twenty trees of the Duchess apple, the fruit of which had already begun to show signs of being marked by the Plum Curculio. When the apples were picked, while the unsprayed trees bore only 75% of marketable fruit, 82.5% of perfect fruit was taken from the sprayed tree—a slight advantage in favor of the sprayed tree. On these trees only two sprayings were given, both after the fruit had formed. In picking up windfalls, a slight difference was noted in the number from the sprayed and unsprayed trees. Fifteen thousand were picked up from under an unsprayed tree, while 13,800 were found under a sprayed tree, the two trees being about equal in size. This data is not sufficient to base any conclusions in regard to Grasselli's mixture.

At the suggestion of the writer eight or nine hundred other apple trees were sprayed in this same orchard during the spring of 1908, Paris green and arsenate of lead each being used once, with Bordeaux mixture. At the time of our first visit the Curculios were very abundant among these trees, and much of the growing fruit was already marked, so the advice was "Spray at once thoroughly." As arsenate of lead was not immediately available, Paris green (one-half pound) was used with the Bordeaux mixture (5

lbs. copper sulphate, 6 lbs. lime and 50 gals. water) for the first spraying, arsenate of lead (3 lbs.) being employed with the Bordeaux mixture (same proportions as above) for the second spraying.

The spraying apparatus was faulty, and the trees were not sprayed nearly as thoroughly each time as they should have been, yet comparatively good results were obtained. In 1907, when no spraying was done, this fruit grower had a small crop of apples, and even what he had were very badly marked with the curculio and scab, but this year over two thousand bushels of good clean apples were picked, the orchardist receiving an average of over a dollar per bushel for them.

SUMMARY.

1. Spraying plum trees with Arsenate of Lead and Bordeaux Mixture (3-4-50) two or three times at beginning of Curculio season, at intervals of a week or ten days will prevent at least 50% loss of fruit from Curculio injury, to which must be added whatever injury from fungi is saved by the use of Bordeaux mixture.
2. Spraying apple trees at the same time will, as our experiments and the experiments of others show, control not only the Curculio on the apple, but the Codling Moth as well.
3. The spraying before the blossoms open gives a result decidedly in favor of such spraying. If, however, only two sprayings can be given, the second (May 27th in 1908), and third (June 4th in 1908) are the most effective.
4. Cultivation during July and August, or turning hogs in to gather up windfalls is an effective method of control.

SOME DESTRUCTIVE SHADE TREE PESTS.

THE OAK PRUNER.

Elaphidion villosum Fabr.

Fig. 36. The Oak Pruner, *Elaphidion villosum* Fab. Beetle, larva, and lavra in burrow. Original.

However desirable it may be to have a judicious pruning of our oaks, we can hardly trust to this beetle to do the work as we wish it done, and during the summer of 1908, *Elaphidion* has certainly exceeded the limit and caused much anxiety to owners of oak trees in various parts of the state. Further, since it sometimes attacks the apple and other quite valuable trees, it calls for some attention.

During July of the present year one may have observed beneath our oak trees many fallen twigs, and in some instances small branches, with leaves still attached, and generally withered, though sometimes still green. A glance into the tree would reveal possibly other twigs hanging suspended, with wilting or wilted leaves, not yet dislodged by the wind. The pieces on the ground, when examined, exhibit a clean cut or break at the large end, and if one cuts into the twig with a knife, a whitish worm is disclosed lying in the burrow thus opened. This is the larva of the Oak Pruner, which when full grown, is a little more

than one-half inch long, and transforms into a blackish or brownish-black beetle of about the same length.

The life history of this pest is such, evidencing apparently marvelous instinct, that it commands our admiration. The female beetle, according to Fitch, normally lays her eggs in spring or summer on a green succulent twig in an angle between leaf twig and leaf stalk. This action affords the young tender food of the right nature, easily obtained. As the larva grows older it works into the older wood. At this time the "worm" is about half grown. According to the above writer and others, this larva needs moisture to go through with its transformations to the pupal and later to the imago stage. This evidently it could not obtain if the twig remained on the tree. It therefore, proceeds to cut off the twig which has afforded it a home, so that this will lie on the moist earth during the autumn and winter. This is a very nice operation, evidencing apparently, as stated above, remarkable instinct. Fitch tells the story so nicely that we reproduce here his account:

"The worm, being about half grown, is now ready to cut the limb asunder. But this is a most nice and critical operation, requiring much skill and calculation, for the limb must not break and fall while he is in the act of gnawing it apart, or he will be crushed by being at the point where it bends and tears asunder, or will fall from the cavity there when it breaks open and separates. To avoid such casualties, therefore, he must after severing it have time to withdraw himself back into his hole in the limb and plug the opening behind him before the limb breaks and falls. And this little creature accordingly appears to be so much of a philosopher as to understand the force of the winds and their action upon the limbs of the tree, so that he can bring them into his service. He accordingly severs the limb so far that it will remain in its position until a strong gust of wind strikes it, whereupon it will break off and fall.

"But the most astonishing part of this feat remains to be noticed. The limb which he cuts off is sometimes only a foot in length and is consequently quite light; sometimes ten feet long, loaded with leaves, and very heavy. A man by carefully inspecting the length of the limb, the size of its branches, and the amount of foliage growing upon them could judge how far it should be severed to insure its being afterwards broken by the winds. But this worm is imprisoned in a dark cell only an inch or two long in the interior of the limb. How is it possible for this creature, therefore, to know the length and weight of the limb and how far it should be cut asunder? A man, moreover, on cutting a number of limbs of different lengths so far that they will be broken by the winds, will find that he has often miscalculated, and that several of the limbs do not break off as he designed they should. This little worm, however, never makes a mistake of this kind. If the limb be short it severs all the woody fibers, leaving it hanging only by the outer bark. If it be longer a few of the woody fibers on its upper side are left uncut in addition to the bark. If it be very long and heavy not more than three-fourths of the wood will be severed. With such consummate skill and seemingly superterrestrial

intelligence does this philosophical little carpenter vary his proceedings to meet the circumstances of his situation in each particular case! But by tracing the next stage of his life we shall be able to see how it is that he probably performs these feats which appear so much beyond his sphere.

"Having cut the limb asunder so far that he supposes it will break with the next wind which arises, the worm withdraws himself into his burrow, and that he may not be stunned and drop therefrom should the limb strike the earth with violence when it falls, he closes the opening behind him by inserting therein a wad formed of elastic fibers of wood. He now feeds at his leisure upon the pith of the main limb, hereby extending his burrow up this limb six or twelve inches or more until he attains his full growth—quietly awaiting the fall of the limb and his descent therein to the ground. It is quite probable that he does not always sever the limb sufficiently, in the first instance, for it to break and fall. Having cut it so much as he deems prudent, he withdraws and commences feeding upon the pith of the limb above the place where it is partically severed, until a high wind occurs. If the limb is not hereby broken, as soon as the weather becomes calm he very probably returns and gnaws off an additional portion of the wood, repeating this act again and again, it may be, until a wind comes which accomplishes the desired result. And this serves to explain to us why it is that the worm severs the limb at such an early period of his life. For the formidable undertaking of cutting asunder such an extent of hard woody substance, we should expect he would await till he was almost grown and had attained his full strength and vigor. But by entering upon this task when he is but half grown he has ample opportunity to watch the result, and to return and perfect the work if he discovers his first essay fails to accomplish the end he has in view."

Fitch claims that the entire larval and pupal stage is passed within the twig. From personal observation, however, we are led to believe that such may not always be the case. Our attention was called by a correspondent in August, to the fact that many fallen twigs examined contained no worms. Later, in September, we noted this also, and were not able to find a single larva in any twigs examined, a large number being cut open for examination. This can hardly be accounted for by the work of insectivorous birds, since they would be unable to reach them in their burrows. In any event the larva is in its burrow when the twig first falls, and can then be easily cared for. We therefore, suggest the following:

Remedy: *Collect and burn all twigs cut off by this insect as soon as they are found on the ground in July or August. Do not leave this work until the following spring.*

THE AEGERIID ASH BORER,

Podesesia (*Aegeria*) *fraxini* Lugger.

Fig. 37. The larva of the Aegeriid Ash Borer. Original.

This is a whitish caterpillar, with a few hairs sparingly scattered over its body, which bores in the solid wood of the Ash, greatly weakening the trees, and sometimes causing them to break. It is particularly destructive where ash trees are grown for wind-breaks in Minnesota, South Dakota and Montana. The entire trunk and larger branches are susceptible to attack. The larva becomes a dark-colored clear-winged moth with yellowish markings. The eggs are laid by the female on trunk and branches. A real estate company with large holdings at Columbia Heights complained to us during the summer of 1908 regarding this pest, claiming that quite large ash, with trunks three to five inches in diameter, planted as shade trees, were being riddled. Examination showed this to be the work of the above borer. We advised the following treatment:

Remedy: *Inject with medicine dropper into the opening of each burrow about one-half teaspoonful of bisulphide of carbon, immediately plugging the opening with mud, clay or putty. The gas generated is deadly to insect life. Avoid bringing a light near this liquid.*

THE STALK BORER AS AN ASH INSECT.

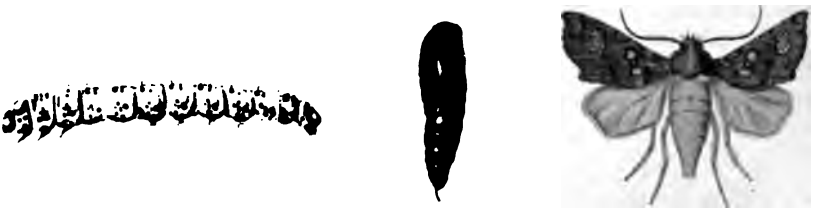


Fig. 38. *Papaipema furcata*, larva, pupa, and moth. Original.

In July, 1908, there were sent to us from a large nursery many cuttings of young ash from nursery rows, with the statement that hundreds of young trees were so affected that they broke down with the slightest wind, and were thus rendered valueless. The holes where this worm entered were plainly visible on the shoots. This borer proved to be one of our old friends?, the Stalk Borer, *Papaipema furcata*, which has a predeliction for garden flowers, but has also evidently found young ash trees to its liking.

We wrote this party that possibly the borer could be killed by introducing a wire into its burrow, or, in some cases, might be cut out, avoiding wounding the tree any more than is necessary. We also suggested spraying the growing trees in the early spring with some

rong, soapy solution which contained Paris green, or better, with senate of lead, since the latter is more lasting. The latter could be ed very strong, six or eight pounds to fifty gallons of water, with rfect safety. A second spraying four weeks after the first would be eful. This would serve, in a measure, to protect the trees. What- er treatment were resorted to, the individual grower would have to cide which was the most practicable for his individual needs. Where e price of trees warrants, or their numbers make it possible, the bisul- ide treatment could be given, as advised under the preceding insect.

THE LOCUST BORER.

Cyllene robiniae Forst.

Fig. 39. Young Locust tree injured by Locust Borer and later broken by the wind. After J. S. Houser, Ohio Bul. 194.

Fig. 40. Adult Locust Borer. Original.

This beautiful beetle, black with golden markings, nearly three-fourths of an inch long is a common pest of locust trees in Minnesota. In the fall it occurs on the flowers of goldenrod. Branches and sometimes an entire tree succumb to its attacks. Dr. Harris has beautifully described the life history of this pest, and we are led to give the exact words in this connection:

"In the month of September these beetles gather on the locust trees, where they may be seen glittering in the sunbeams with their gorgeous livery of black velvet and gold, coursing up and down the trunks in pursuit of their mates, or to drive away their rivals, and stopping every now and then to salute those they meet with a rapid bowing of the shoulders, accompanied by a creaking sound, indicative of recognition or defiance. Having paired, the female, attended by her partner creeps over the bark, searching the crevices with her antennae, and dropping therein her snow white eggs, in clusters of seven or eight together, and at intervals of five or six minutes, till her whole stock is safely stored. The eggs are soon hatched, and the grubs immediately

Fig. 41. Eggs of Locust Borer, much enlarged. After J. S. Houser, Ohio Bul. 194.

burrow into the bark, devouring the soft inner substance that suffices for their nourishment till the approach of winter, during which they remain at rest in a torpid state. In the spring they bore through the sapwood, more or less deeply into the trunk, the general course of their winding and irregular passages being in an upward direction from the place of their entrance. For a time they cast their chips out of their holes as fast as they are made, but after a while the passage becomes clogged and the burrow more or less filled with the coarse and fibrous fragments of wood, to get rid of which the grubs are often obliged to open new holes through the bark. The seat of their operations is known by the oozing of the sap and the dropping of the sawdust from the holes. The bark around the part attacked begins to swell, and in a few years the trunks and limbs will become disfigured and weakened by large porous tumors, caused by the efforts of the trees to repair the injuries they have suffered. According to the observations of Gen. H. A. S. Dearborn, who has given an excellent account of this insect, the grubs attain their full size by the 20th of July, soon become pupae, and are changed to beetles and all leave the tree early in September. Thus the existence of this species is limited to one year."

Remedies: *Some repulsive wash, containing arsenate of lead, ur to six pounds for every fifty gallons, applied to trunks and larger anches in the early fall would be beneficial. Cutting down and burn- 7 of badly infested trees during the winter or early spring. Some mpound containing whale oil soap or other soap with the ad- tion of a liberal supply of powdered sulphur or crude carbolic acid both, and whitewash, might be used as a repellant, to which the senate of lead could be added as indicated.* The poison is added in der to kill young borers as they enter the tree, should any beetle nture to lay her eggs in crevices of the bark in spite of the presence the repellant wash. The fact that the adult beetles frequent golden- d in the fall would prompt one to keep this plant away from the roximity of locust trees. It has been suggested that, in coating the unks of trees in parks and on private grounds with anything of the ature of whitewash, lamp black or some similar coloring matter could e added to the wash, making the latter harmonious in color with the ark of the treated tree, and thus avoid the glaring effect of a *white-* vashed trunk.

THE BOX ELDER MAPLE BORER.

A new pest of the Box Elder in Minnesota, affecting the young twigs. This was frequently complained of during the summer of 1908.

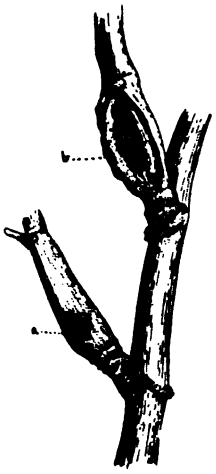


Fig. 62. Box Elder Twig injured by the Maple Borer, a and b marking respectively early and later stages of injury. Original.

This insect was reared in the insectary, and proves to be a Tortricid.

It was first collected upon the Station grounds on July 2nd, 1908. On July 17th pupae were found in numbers, some in cocoons outside of the twigs, and some inside of the burrows in the twigs. Moths emerged between July 21st and July 30th. Some of these were transferred to a small Box Elder in breeding cage, and although no eggs were observed, we found on August 4th small caterpillars were feeding upon the leaves, later boring into the top of the plant, and at this date appear to be working down the stem.

Manifestly collecting and burning infested twigs the latter part of June and during July would be a desirable way to lessen their numbers. From examination of females sent him, C. H. Fernald believes this to be *Proteoteras esculanum* Riley.

Fig. 43. Larva, pupa and adult of Maple Borer. Original.

THE BRONZE BIRCH BORER,

Agrilus anxius Gory.

The illustration given herewith, Fig. 12, shows excellently the work of this pest. Birches on the Experiment Station grounds have been badly affected, a number dying during the summer of 1908, apparently as the result of its work. It attacks the Cut-leaved Birch and both the Yellow and White Birch. It is also recorded from poplar and from willow.

Borers nearly or quite full grown were taken from White Birch here on September 19th, from trees which were first noticed to be dying about July 15th. In many cases some of the smaller limbs appeared to have been killed by attacks of the insect in 1907. From the photograph one will readily see that these borers work just under the bark, practically girdling it, though they also go deeper into the wood.

The borer winters under the bark in the larval stage, pupating in the spring, the adult beetles emerging a little later, possibly in early June in Minnesota. By the latter part of July and during August young larvae are at work under the bark, their presence being recognized by a red color, and indications of the course of their burrows by raised ridges on the bark. The larva apparently may leave the cambium layer in the fall and work into the wood, where, in a cavity which it prepares, it passes the winter, pupating the following spring or early summer. The tops of the trees are attacked first, dying as a result of its work; yet Dr. Franklin reports that "limbs evidently killed the previous year were, as a rule, among those nearest the ground."

Remedies: *The destruction by cutting and burning of all infested trees during the winter or very early spring before the appearance of the adults. Do not leave any infested part of the tree standing.*

Dr. E. P. Felt, of New York State, thinks that some of the injury done by this beetle is due to leaving a portion of the trunk standing enough borers remaining under the bark to carry infestation to othe trees. These stumps are sometimes left for the support of flowe

oxes. Birches on our private grounds and parkways should be carefully watched, and if any portion is observed to be dying, careful search hould be made for this pest. In cutting off any portion of an infested ree, care should be taken to see that no borers are left in bark of the ortion still standing.

Fig. 44. Work of the Birch Borer. Original.

THE WHITE PINE LOUSE; PINE BLIGHT; PINE BARK APHID,

Chermes pinicortis Fitch.

Our illustration shows very well the white wooly growth which covers these minute aphids, which, by sucking the sap from white pines, greatly weakens and eventually kills the tree. It is a common insect in Minnesota, and we have received a number of complaints

Fig. 16. The White Pine Louse on bark of pine tree. Original.

regarding it, besides personally noting its injurious work on pines in the vicinity of the Twin Cities. It has been noticed and studied in the United States since 1856. People unacquainted with the fact that this white flocculent matter is a growth from insects, regard it as some form of plant disease, and hence the name of "Pine Blight."

Whether this insect hibernates in some one of its forms on some food plant other than the pine, or in the ground near the tree affected, or upon the affected tree itself, is apparently not known to entomologists at the present time. Our knowledge of its exact life history, then, is not complete, but we are in possession of some facts for which we are indebted to E. L. Storment (20th Rep. Insects of Ilinois, 1898), who has evidently spent much time and study upon this somewhat unique insect.

The eggs hatch, five to sixty in a mass, in the latitude of Illinois, arly in May usually, having been laid in the wooly masses covering ıe female lice. For a time the young are active and crawl over the :ees (probably in the latter part of May and early in June in Minneota). Their activity soon ceases and they attach themselves to both wigs and branches, become dark colored, though on account of the vhite wooly covering their presence is easily detected. Winged emales are produced in June, and by these other parts of the tree and :ther trees may be infested. The winter, as stated above, may be)assed in some one of its stages. Storment claims that there are everal broods in a season, and that wingless females do sometimes ıibernate and begin their egg laying in April (Illinois), eggs hatchng about the middle of that month. Much has yet to be learned regarding the life history of this insect, and it offers an inviting field for ;tudy.

Remedies: *Several predaceous insects eat this louse, notably the arvae of some "lady bird" beetles, of Syrphus Flies, etc. Kerosene :mulsion, about one part of stock solution to nine or ten gallons of vater, if used in a forceful spray early in spring, will kill this insect, nd, it is claimed, the eggs also are destroyed by kerosene emulsion. A whale-oil soap spray, one pound to four gallons, might do equally well. A very forcible spray of water alone would doubtless wash away nd kill many of the insects.*

Storment claims that the best time to spray is in the winter, since at that time the beneficial insects which prey upon the louse are not destroyed. His advice is evidently based upon the theory that the lice hibernate in some form on the tree itself.

ALDER BLIGHT, ALDER APHID,

Pemphigus tesselatus Fitch.

Like the preceding, this dark-colored louse, infesting the Alders, is covered with a copious white flocculent growth, making it very conspicuous. The insects secrete a so-called "honey dew" which drops to the leaves below, and in which grows a fungus (identified by Dr. Freeman as *Scorias spongiosa*), this growth giving a dark, blighted appearance to the leaves.

We first noticed this louse on Alders on Lake of the Isles Boulevard in 1902. In October of the same year young were observed ;warming over trunks and branches.

Their life history, it may be said, doubtless resembles in a general vay that of other wooly aphids. This insect is now believed to have n alternate form on the maple (Patch: Ent. News, Dec. 1908).

Remedies: *Same as for preceding. Very badly infested trees ight well be destroyed.*

Fig. 47. Alder infested by Alder Aphid. Original.

THE COTTONY MAPLE SCALE,

Pulvinaria innumerabilis Rath.

This pest, so common on Maples, and in some instances on Elms, has been and is injuriously abundant. It has been thoroughly discussed in previous publications from this department, but as it figures prominently as one of our Shade Tree Pests, we include here a short account of it, and suggest certain treatment. This, with the accompanying illustrations, should give our readers a very good idea of its appearance, and the methods by which it can be combated.

Our illustration shows this insect, which has been extremely abundant on Soft Maple. Maples and Elms as well as various vines and shrubs in St. Paul, Minneapolis, St. Anthony Park and many towns throughout the state, as well as trees in localities in South Dakota and elsewhere, have been more or less affected.

The spreading from tree to tree could be affected, where trees interlace, by the active young crawling from limb to limb, and further by being carried on the feet of birds. In the opinion of the writer, the English sparrow is, in a large measure, responsible for this, for he is pre-eminently now *the* bird of the city and village streets. We must not, however, overlook the agency of insects of various sorts, upon whose bodies the young lice could be easily transported. Prof. Riley, in the first Missouri Entomological Report, comments on this and says, "The copious secretion of honey dew attracts many honey loving insects, such as bees, wasps and flies, and these without doubt carry many of the restless young larvae from tree to tree." Spiders, also, are said to assist in this work, and even the beneficial "Lady Bird" beetles which prey upon the scale. The wind, too, in blowing infested leaves or twigs from one place to another, also plays a part in distributing this insect.

Ordinarily a strong, vigorous tree can withstand considerable sapping of this sort without being appreciably weakened, but when the pest is as abundant as it has been recently, their pernicious work is bound to show, in the sickly appearance of some of the branches of the maples.

Remedies: *If trees are trimmed in winter or early spring, and the cuttings burned, the adult scales on the cuttings, with many thousands of eggs, will be destroyed. The same result would be obtained* ***pruning and*** *burning in the late summer and fall. Sprayings of* ***kerosene emulsion*** *in the spring and early summer will kill the young lice as they are crawling over branches and leaves, and strong caustic sprays, such as lye, or lime and sulphur, applied in winter when the*

Fig. 18. Maple trees infested by Cottony Maple Scale in a town in southern Minnesota. Original.

Fig. 48a. Cottony Maple Scale. Original.

trees are dormant, will kill the adult scales and the contained eggs. Spraying a tall tree, however, is difficult and sometimes impossible. When but a few are present on a vine or shrub they may easily be got rid of with a bucket sprayer, or even killed by touching them with kerosene. Or they may be picked off and destroyed.

This scale has many natural enemies, both predaceous and parasitic, which unknowingly assist us in our work against it.

Life History: It belongs to the family Coccidae, which contains all the scale insects, and its life history resembles in general that of other scales. Briefly, the young lice hatch in the spring and early summer, immediately migrate to the leaves, and temporarily become fixed. Sucking the sap from the leaves, they rapidly increase in size, moutling a number of times as they grow. The scales undergo a metamorphosis, emerge from pupal case as minute two-winged insects, mate with the females and die; the impregnated females later migrate to the twigs and pass the winter fixed to the same. The following spring the developing eggs cause the body of the female to increase in size, and late in May and in June these eggs are laid in the cottony growth which the female has secreted at the posterior end of the body. In the above photograph the cottony (waxy) secretion is full of eggs. After laying from 1,000 to 2,000 eggs the female dies, probably in July.

The insect feeds not only on the trees above indicated, but upon various species of maple, upon wild grape, oak, basswood, hackberry, currant, locust, sumac, box elder, willow, woodbine (Ampelopsis), etc.

FALL WEB WORM,

Hyphantria cunea Dru.

Fig. 49. Work of Fall Web Worm. Original.

Two years ago attention was drawn to numbers of unsightly
on leafless trees, observed in different parts of the state,
marked the work of the Fall Web Worm (*Hyphantria cunea* I
during the preceding summer. These were mostly seen in patcl
woodland bordering pastures and elsewhere, and occasionally
fruit and shade trees. On account of their numbers, and from th
that their work was not, for the most part, in conspicuous situa
thereby securing for themselves immunity from molestation, n
prediction was made that their numbers would be very largely inci
later. This turned out to be the case, and since land owners
whose property they occurred this year have taken very little, ar
the most part, no steps to eradicate them, their occurrence in
numbers is to be regarded of vital importance to fruit growers,
commissioners and others who are interested in preserving tree
shrubbery in parks and in private grounds.

This is the more to be deplored since perhaps none of our
lends itself more readily to preventive measures, if the suffere
but put in practice a simple method at the very first appearai
its work. Arsenical sprays, it is true, are not as efficacious in th
of this insect as with some other leaf-eaters, since the web
covers the small branch, or cluster of leaves upon which it is fe

ith a fine web, thus in a measure preventing the successful coating f the leaf with poison. Yet an application of four to six pounds of rsenate of lead (Disparene) in a hundred gallons of water, upon the oliage not so covered, which will be later attacked, would bring bout the desired result. Further, a spray applied when the worms re newly hatched will be effective before they have begun to spin web. The simpler method above referred to is *to break off the "web" or nest when first observed, before any serious injury has been done, and burn it with the contained worms, or crush them under foot.* The only obstacle, and one which can be readily overcome, to the successful working of this method, is the fact that their work may escape observation until a small tree is nearly defoliated, or neglect to destroy the nests when first seen. It is to be noted that their nests are deserted in the fall; hence destroying these at this time is not effective.

ITS OCCURRENCE AND FOOD PLANTS IN 1907.

While observed in various parts of the state last summer, its work was most apparently localized in the southwestern corner of Hennepin County, along the line of the Great Northern railroad, in the vicinity of Lake Minnetonka. Going from Minneapolis to Mound on this road, one curiously enough first notices their unsightly nests in the neighborhood of Spring Park, and these become more abundant as Mound is approached. In the vicinity of the latter town, within a radius of about five miles, it has been exceedingly abundant the past two summers and evidences of its work are on every side. It has attacked pig-nut, basswood, elm, maple, birch, box elder, plum, apple, lilac, sumac, wild gooseberry, etc. In fact, it appears to be a general feeder though it shows a marked predilection for pig-nut.

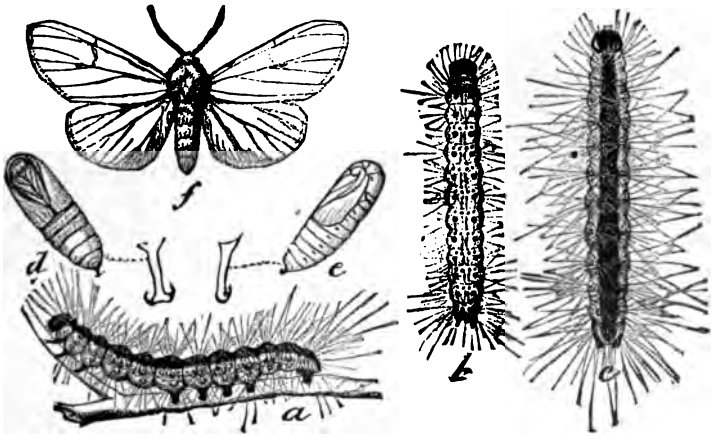


Fig. 50. The Fall Web Worm: *a*, dark covered larva from the side; *c*, the same from above; *b*, light covered larva; *d*, pupa from below, *e*, same from side. Bureau of Entomology, U. S. Dept. Agrl.

An idea of its present abundance in this section may be gained from the fact that a farmer of our acquaintance counted in a small piece of woodland several hundred of these "webs" in the morning sunlight after a night of fog had left the nests conspicuous.

They work mostly at night, for they were generally observed to be quiescent during the day, while a light flashed upon them at night revealed them as being extremely active within the web, rapidly devouring the leaves they had enclosed, and extending their web over other leaves.

ITS LIFE HISTORY.

The moth is characteristically white in color, at least in Minnesota, but its wings are frequently marked with spots, and the variations are so marked that the insect has in the past received two or three different specific names on this account. Lugger (Fourth Annual Report, Minnesota Entomologist) states that breeding them in confinement has proven these markings to denote simply variations of the same species.

The female lays its eggs at night, in a cluster, on a leaf of its food plant, one female being capable of depositing four hundred or more eggs. The egg (about 1-50 inch in diameter) is light yellow, round, and its surface ornamented by indentations easily seen with a lens. The eggs hatch in about ten days, sooner if the weather is warm, and the young caterpillar at once begins its work of destruction. In states where there are two broods, it is calculated that the offspring from a single female could reach, under favorable conditions, the astounding number of 125,000 caterpillars in a season. Even in Minnesota, where, it is believed, we have only one brood, the progeny of one female may reach the 500 mark, and it is this fecundity, and the very generally prevalent habit on the part of our citizens of overlooking its work, that the entomologist wishes to emphasize as an alarming feature in connection with our trees.

The newly hatched caterpillars are yellowish and hairy, with a black head, as they grow older they may change to greenish, or become paler or darker, showing a marked variation in this respect.

The web, which is made larger as the caterpillars grow older, spreads over the branch, or to other branches, and finally filled with the remnants of the eaten leaves, with the moulted skins of the caterpillars and with their excrement becomes disgustingly prominent.

In a month or six weeks these caterpillars are full grown, a little over an inch long. They spin their cocoons in sheltered places, in the litter on the ground beneath the tree, in clefts and crevices in

the bark of trees, fences, etc. In these secure retreats (where they are at this date) each caterpillar changes to a brown pupa, which emerges as a month in the spring, mating and egg-laying quickly following its emergence. Parasites undoubtedly play a part in the life history of this pest, and this department plans to rear them to determine their abundance and the species.

No insect better illustrates the efficacy of "an ounce of prevention" than the Fall Web Worm, and before this unpleasant and dangerous feature becomes too conspicuous in our parks and boulevards, and in the beautiful private grounds in which the citizens of Minnesota take so much pride, it is to be hoped that a little vigilance and prompt action will be exercised when and wherever it makes its appearance.

THE POPLAR LEAF BEETLE,

Melasoma scripta Fab.

Fig. 51. The Poplar Leaf Beetle, enlarged and natural size. Original.

Very destructive to nursery trees and windbreaks. In addition to Poplar, it feeds also on Cottonwood and on Willows. The young grubs feed for a time on the under surface of the leaves, later consuming the entire leaf. The pupa is found suspended from the leaves during the summer.

Remedies: *Spraying with arsenate of lead, having added enough soap to the solution to make it spread evenly over the leaf. The addition of soap is especially desirable when the smooth leaves of willows are sprayed, since the ordinary sprays are apt to roll off the smooth surface. The under side of the leaf, as well as the upper, should be hit by the spray, where possible, in order to poison the very young grubs feeding there.*

The colonies of grubs may also be knocked off the leaves by jarring into a receptacle containing kerosene oil, or water and oil.

CURTIS SCALE.

Aspidiotus [illegible]

Fig. [illegible]. Curtis Scale. Original.

The accompanying illustration shows very well the appearan this scale. believed to be Curtis Scale which was submitted t during the summer of 1[illegible] by the forester of the Minneapolis Board, he being under the impression that it was the much dr San Jose Scale. The presence of the latter is recorded in Wisc and South Dakota, therefore Minnesota nurserymen and orcha should be on the watch for this pest.

Fig. 52. San Jose Scale. *a*, infested twig, natural size; *b*, bark with different stages of scale, much enlarged. Bureau Entomology, U. S. Dept. Agriculture.

General remedies for scale insects are given below.

THE SCURFY SCALE,

Chionaspis furfura Fitch.

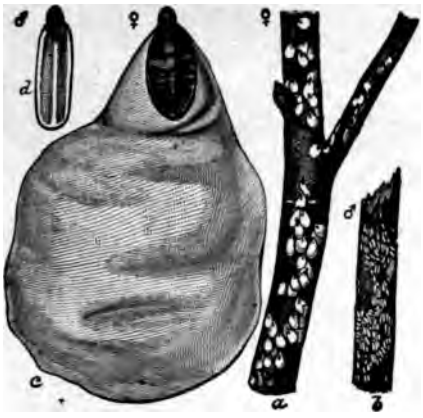


Fig. 54. The Scurfy Scale. Bureau of Entomology, U. S. Dept. Agriculture.

Exceedingly abundant in Minnesota, giving trunks and branches of affected trees a "scurfy" appearance. This scale is oval, somewhat elongated, about one-tenth of an inch long, pointed at one end and white. It affects poplars, cottonwood trees, mountain ash, willows (in one instance a grove of the latter were found in 1908 to have been destroyed by this insect) and other trees and shrubs. A form belonging to the same genus is found on the elm. In the winter, eggs are found under the scale of the female. The young hatch in the spring, move about on the tree for a while, and then settle down to a sedentary life, sucking the sap from the tree, and secreting a scale. There is probably but one generation.

Remedies: *A spray of kerosene emulsion, one part of the stock solution to nine or ten of water applied to infested trees in spring about the first of June, would kill the young if they had hatched. Two sprayings with this solution, one the last of May and one about June 15th in this latitude, should insure the killing of the young on trunk and branches. The lime-sulphur washes in winter, when the trees are dormant, is a killing spray for adult scales. All necessary pruning should be done before spraying, and the infested cuttings immediately burned. Careful scraping of infested bark will remove many scales without injuring the tree.*

THE WHITE MARKED TUSSOCK MOTH,

Hemerocampa leucostigma Sm. and Abb.

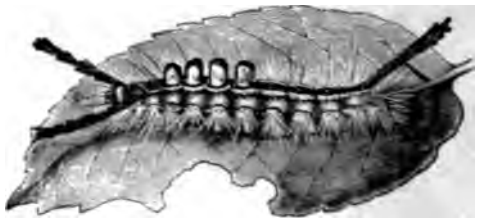


Fig. 55. White Marked Tussock Caterpiller after Riley. Bureau of Entomology. U. S. Dept. Agrl.

When full grown one of our most beautiful caterpillars, immediately recognized by the four white tufts or tussocks on back. The head is bright coral red, and the body marked with longitudinal yellow, gray and black lines. Below the caterpillar is yellow. There are two tufts of black hair projecting forward from above the head. At the posterior end of the body there is one hairy "horn."

Fig. 56. White Marked Tussock Moth, wingless female, about to lay her eggs on cocoon. After J. S. Houser, Ohio Bul. 191.

This "worm," when full grown, has been feeding for a month, and is about an inch long. At that time it spins for itself a hairy cocoon. This may be on the tree where it has been feeding, or upon other trees, or upon buildings, fences, etc. Two weeks are spent in this cocoon, at the expiration of which time the moth emerges. The male moth is gray. The female moth *has no wings*. She lays her eggs in a whitish mass on her cocoon and then dies. This egg mass with the cocoon is a conspicuous object, and when it is known that the eggs of the female number from two hundred to four hundred, the importance of gathering and destroying the egg masses before hatching time is very apparent. This pest is a general feeder, a variety of trees and vines suffering from its depredations.

Fig. 57. Elms defoliated by White Marked Tussock Moth. After J. S. Houser. Ohio Bul. 194.

nedies: *Collecting and destroying the egg masses. On large here masses cannot be reached, moisten them with a sponge d with creosote and tied to a pole. Spraying with arsenicals te of lead, three pounds to fifty gallons of water is best) at when they are eating the leaves. To prevent caterpillars from ig keep trunks banded during the summer with cotton, or some naterial, such as tree tanglefoot. In cases of bad infestation, some of the above remedies.*

Fig. 58. Horse chestnut defoliated by first brood of larvae. Tree sprayed at that time with strong kerosene emulsion and banded with Tanglefoot. After J. S. Houser, Ohio Bul. 158.

Fig. 59. Same tree as in Fig. 58 forty days after treatment. Tree putting out new crop of foliage. After J. S. Houser, Ohio Bul. 191.

This insect is badly parasitized, for which, as it keeps their numbers down in normal years, we may be profoundly grateful.

THE FOREST TENT CATERPILLAR,

Melacosoma disstria Hubn.

Fig. 60.

At times of a serious outbreak this is a destructive pest to shade trees in Minnesota. In a general way it resembles the Orchard Tent Caterpillar. It spins no "tent," however, but coats branches or trunk, wherever it passes, with a silken web. The brownish moth lays its eggs, a hundred or more, in a band about the twigs of its food plant in the latter part of the summer, and there hatches the following spring just after the leaves begin to unfold. When full grown the caterpillar is about two inches long, hairy, a row of white spots down

the back; on the sides yellowish and black stripes. General color bluish. It spins its cocoon on trees or in crevices of bark or fences, on withered leaves, etc.

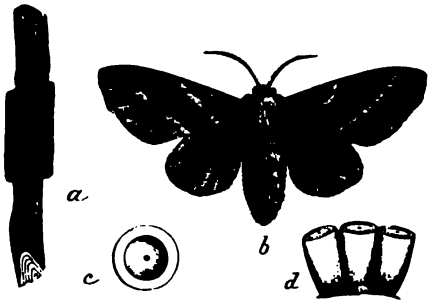
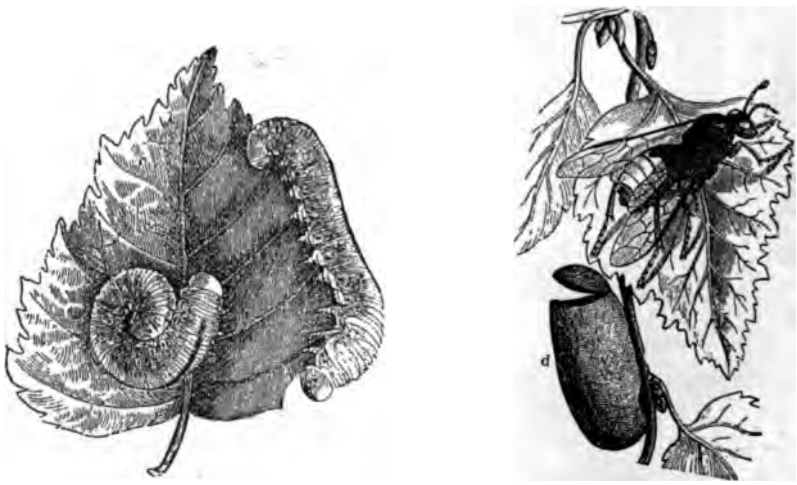


Fig. 61. Egg mass, *a*; eggs, *d* and *c*; moth, *b*; Forest Tent Caterpiller.

Remedies: *Cutting off and destroying egg masses in late fall. Spraying the foliage in spring when caterpillars appear, with arsenicals, notably arsenate of lead, three pounds in fifty gallons of water, which will not burn the leaves. Banding of trees to prevent ascent of caterpillars.*

WILLOW SAW FLIES, WILLOW SLUGS.



Figs. 62 and 63. *Cimbex americana:* larvae, cocoon and adult. Natural size.

The foliage of our willows is sometimes more or less injured by Saw fly larvae, or "false caterpillars" which eat the leaves. Even the laurel-leaved willow, which, happily, is not so much subject to insect attack as some other varieties, is not exempt.

These false caterpillars, differing from the true caterpillars in ng from twelve to sixteen fleshy pro-legs in addition to their true legs, belong to the order Hymenoptera, and the adults of both ies which affect willow with us are four-winged flies, not ordi- y noticed by the casual observer.

The larva of *Cimbex americana,* Leach, has a habit of curling up ie leaf as shown in the illustration. It is greenish or pale yellow- with a black stripe down the back. They also have the power, it id, of ejecting an acid fluid from pores in their skin. When full m they spin a papery cocoon, changing within to pupae, and ging later as four-winged flies. The American Cimbex is the est Saw Fly we have, resembling somewhat a hornet in size and ral appearance. The eggs are laid in the tissue of the leaf. It ts elms and some other trees as well as the willow.

A second species occurring here is *Pteronus ventralis,* Say; the ı or "caterpillar" of this saw fly being black with yellow spots on ides.

Fortunately, both of these insects yield readily to arsenical ons. A weak combination of Paris green and water, or, better ate of lead and water, applied to the leaves will kill them.

THE ELM CATERPILLAR; MOURNING CLOAK.

Euvanessa antiopa Linn.

Fig. 64. Mourning Cloak Butterfly. Original.

Early in April and sometimes in March one frequently sees this ing butterfly in sheltered spots in Minnesota groves, for this in- hibernates in the adult stage. It is strikingly colored, having wings

which are almost black, with a light yellow margin. The female lays her eggs upon twigs of different trees (for the most part on elms in Minnesota) and the newly hatched larvae begin to feed upon the leaves as soon as hatched, the individuals of the colony keeping well together. When full grown the caterpillar is black with red spots on the back, its body covered with formidable looking branched spines. The chrysalid hangs from a twig or branch of the tree upon which the caterpillar has attained its full growth, at which time it is nearly or quite two inches long.

Remedies: *Spraying with arsenate of lead as for the previous insect, or collecting and destroying the caterpillars when first seen.*

THE ELM LEAF BEETLE,

Galerucella luteola Mull.

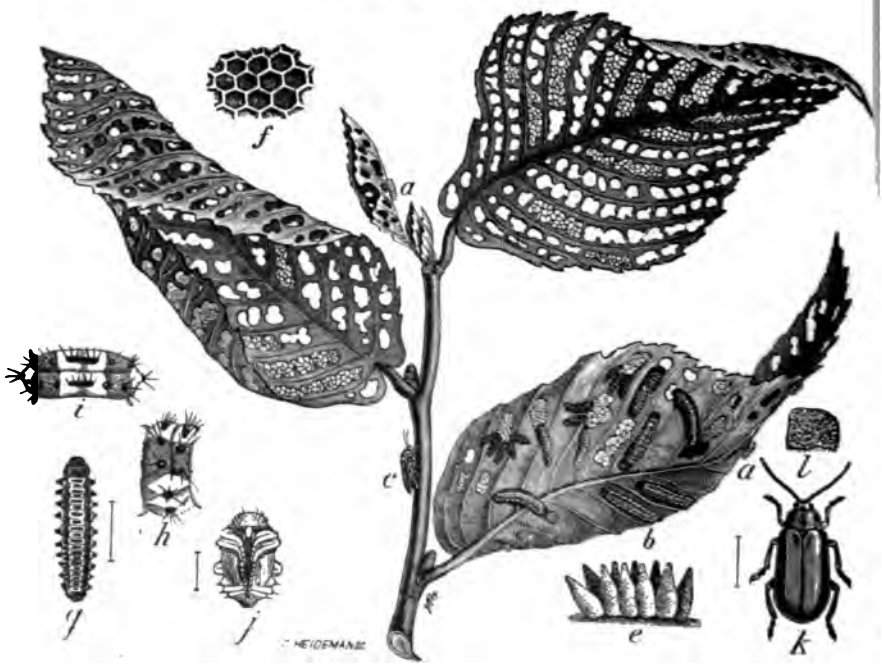


Fig. 65. Elm Leaf Beetle, different stages and work. Bureau of Entomology, U. S. Dept. Agr

We figure this destructive pest here in order that our citizens may be familiar with its appearance. It has not yet been found in this state by the Entomologist. Perforated elm leaves a few years ago at first led one to believe it present, but a careful examination failed to reveal it, and we have to seek other causes for the perforations

erred to. Some time since the attention of the department was ed to the leafless condition of portions of the elms in a certain part the Kenwood district, and the numerous holes in the leaves, the er reminding one forcibly of the work of this beetle. It was later ieved to be due to the smoke from the railroad. This may be, in t, the cause of the defoliation, but the perforated elm leaves are nd in other parts of the city where smoke is not so bad; hence, in ault of finding any insect at work, we are forced to conclude that ne plant disease is the cause.

Fig. 66. Tree evidently injured by gas. After J. S. Houser.

The Elm Leaf Beetle prefers European elms; in fact, it is a opean insect, imported here, we believe, about 1834, but it will other varieties of elm when its special food supply is lacking. insect is not quite one-half inch long, striped black and green, and rnates as an adult. The eggs are laid by the female on the under of the leaves, in which location the young grub or larva feeds.

Should this beetle reach Minnesota, which is likely, its occurrence will be of such serious import at to call for a special publication, and nothing need be said here upon remedial measures beyond the statement that spraying with arsenicals (preferably arsenate of lead) just as the grubs appear would be beneficial.

SHADE TREES INJURED BY GAS.

We figure here (the cut is from a photograph by J. S. Houser and loaned us by the Ohio Experiment Station) a tree dying apparently as a result of a leak in the gas main. This is quite a common sight in the streets of the Twin Cities, and this injury must be carefully distinguished from that caused by insects. If one cannot detect the presence of insects or their work upon the leafless branches, and there is no evidence of borers in the trunk, suspicion is at once directed toward gas poisoning if gas mains are on that street, and one must, in such a case, attack the gas company instead of making preparations to wage war upon insects. A portion of the bark on the trunk may peel off from trees so affected.

GENERAL SUGGESTIONS.

All of our shade tree pests have not been discussed in this report, attention having been paid to those for the most part notably injurious in the last few years.

Our Basswood trees are injured by a measuring worm known as *Hyperetia tiliaria*, Han. Oak trees this year (1908) have been in one instance defoliated by a leaf-eating caterpillar, *Symmerista albifrons*, Abb. and Sm., and are frequently attacked by the orange-striped Oak Worms, and worms feeding on the Black Walnut (sent in pupal stage, but probably *Datana integerrima*, Gr. and Rob.) were received in the summer of 1908.

It is very evident that all leaf-eating insects may be killed with arsenical sprays, or by hand picking, or by cutting off the infested twig and destroying the insects thereon, or by burning their colonies or webs by means of a torch on a pole, or by crushing them with the gloved hand.

Eggs of many species can be collected in late fall or winter.

Of sucking insects, lice can be killed by a spray of Ivory soap dissolved in hot water (a five-cent cake in six or seven gallons of water), or by kerosene emulsion (this must be prepared and used with care). Young scale insects can be destroyed by kerosene emul-

sion before they secrete a scale, and the adults by the use of lime-sulphur washes when the treets are dormant. Conspicuous scales, like the Cottony Maple Scale, when but few in number on a vine or shrub, can be picked off by hand and destroyed.

Borers can in a measure be kept away by the use of repellant washes (see p. 7) which will stick to the tree, and which should also contain an arsenical poison like arsenate of lead.

As stated above, the glaring effect of whitewash can be prevented by the use of lamp black or other coloring matter in such washes.

The intelligent care of trees is a great aid in our battle with the insects. A tree planted in good soil, vigorous and thrifty, well protected from injury, stands a better chance than one not so favored. A shade tree injured by horses driven by thoughtless grocer boys and others, a young tree scarred by a lawn mower, or a large one either murdered by cut-throat linemen in running electric wires, or burnt by contact with such wires, invites attack, as does also a tree pruned in the wrong way.

WORK WITH THE CABBAGE MAGGOT DURING 1907 AND 1908.

SUMMARY, 1907.

The best results were obtained by treating cauliflower by the method given below. It certainly is an available remedy for a limited number of cauliflower and cabbage, and if the crop brings any price whatever, it would seem that it is practicable for a large acreage of cauliflower.

Steep two ounces of white hellebore in one quart of water for an hour, then dilute with water to make one gallon of the decoction. Larger quantities can be made by increasing the proportions. Apply with watering pot from which the rose has been removed a few days after plants are set out; five days later apply again and a third application five days after the second. Use the solution five or six times more at weekly intervals. It takes approximately between two and three hours to treat 1,000 plants, and the material required for this number costs fifty cents at retail. About a teacupful is poured around each plant.

Fields exposed to breeze suffer less than sheltered fields.

Fields in which the old stalks are not allowed to stand appear to be less affected than fields which are neglected in this particular.

Holland cabbage appears to be exempt from attack, no cabbage maggots being found in this variety.

Red cabbage, on the contrary, is not immune, since it suffers from the attacks of the maggot.

Cabbage maggot flies may emerge from pupae (the hard brown resting stage following the maggot) which are buried five inches deep in the soil.

If it were not for parasites and predaceous enemies, which play an important part in helping the gardener, this pest would be much worse than it is.

In considering recommendations it must be borne in mind that each grower should be guided as to the practicability of certain remedies by the special conditions surrounding him individually. One grower could well use certain methods, which would not be available for another.

These conclusions were published (Circular of Information No. 9) i April, 1908, and mailed to market gardeners throughout the state. lthough it takes but a small space to thus summarize the work, these ew statements represent a large amount of work. Three thousand auliflower plants were used in our experimental garden, besides a arge number of cabbage plants, and in addition, co-operative work vas carried on in truck gardens.

The details of the work of 1907 are given below.

Dipping Plants in Arsenate of Lead: Ten experiments carried out by R. L. Webster, at that time assistant in this division. Rows contained 50 plants each, and the alternate rows were left untreated to serve as checks. The final counts of this lot were made July 24th and 26th, and he results will be found in the accompanying table. The question to be nswered was "Can arsenate of lead, alone, or in combination with other ubstances to make it adhere, be successfully used as a dip with cauliflower nd cabbage to protect them against the Cabbage Maggot?"

The cauliflower plants in this series were set May 17th, and the treatnent first applied at the time of planting. At first only the roots were lipped, but when this method was found too laborious, the entire plant vas immersed. Swift's Disparene was the brand of arsenate of lead used n the ten experiments.

Experiment No. 1, (Row 2.)

Fifty cauliflower plants were first dipped into a soap solution, then nto arsenate of lead and planted immediately. The soap solution consisted f one-half ounce of hard soap dissolved in two quarts of water, and the rsenate solution contained one ounce of disparene (arsenate of lead) to ne pint of water.

Experiment No. 2. (Row 4.)

Fifty cauliflower plants dipped in disparene. One ounce of disparene o one pint of water was used.

Experiment No. 3. (Row 6.)

Fifty cauliflower plants dipped in disparene. One-half ounce of disarene to one pint of water.

Experiment No. 4. (Row 8.)

Fifty cauliflower plants dipped into a solution of disparene, glucose, nd water. The solution contained one ounce of disparene, two ounces f glucose and one pint of water. The glucose was dissolved by boiling nd added to the disparene.

Experiment No. 5, (Row 10.)

Fifty cauliflower plants dipped in a solution of disparene, molasses d water. The solution contained one ounce of disparene, eight ounces molasses (fluid measure) and one-half pint of water.

Experiment No. 6, (Row 12.)

Fifty cauliflower plants dipped into a solution of disparene, molasses and water. This solution contained one ounce of disparene, four ounces of molasses (fluid measure) and 12 ounces of water.

Experiment No. 7, (Row 14.)

Fifty cauliflower plants dipped into a solution of disparene, glue and water. Solution contained one ounce of disparene, one ounce of glue and one pint of water. The glue was dissolved in boiling water before adding to the disparene.

Experiment No. 8, (Row 16.)

Fifty cauliflower plants dipped into a solution of disparene, soap and water. Solution contained four ounces of disparene, one ounce of soap and two quarts of water. The soap was dissolved in boiling water before adding to the solution.

Experiment No. 9. (Row 18.)

Fifty cauliflower plants dipped into a solution of disparene, soap and water. This solution contained four ounces of disparene, one ounce of soap and four quarts of water. The soap was dissolved in boiling water before adding to the solution.

Experiment No. 10. (Row 20.)

Fifty cauliflower plants dipped into a solution of disparene, soap and water. The solution contained four ounces of disparene, one ounce of soap and eight quarts of water. The soap was dissolved in boiling water before adding to the solution.

Tabulating treatment and results we get the following:

Row	TREATMENT	Plants Dead June 4	Plants Dead June 21	Heads	Plants Without Heads	Plants Missing
1	Check	3	5	24	20	6
2	Soap-Disparene	5	6	21	24	5
3	Check	2	1	33	14	3
4	Disparene	2	6	28	16	6
5	Check	1	7	29	12	9
6	Disparene	3	3	27	20	3
7	Check	0	7	20	21	9
8	Disparene-glucose	2	2	25	21	4
9	Check	1	3	30	18	2
10	Disparene-molasses	5	6	16	26	8
11	Check	0	3	28	19	3
12	Disparene molasses	5	3	20	22	8
13	Check	3	7	29	15	6
14	Disparene-glue	7	9	18	27	5
15	Check	6	10	29	9	12
16	Disparene soap	9	8	13	26	11
17	Check	2	2	35	9	6
18	Disparene soap	1	5	25	18	7
19	Check	1	3	23	23	4
20	Disparene soap	2	2	26	20	4
21	Check	0	1	33	16	1

Evidently from this table there was but little difference between treated and untreated rows, and the different applications had but little or no effect. The piece of land upon which these experiments were tried had been sowed the year before, and the maggot was not as bad there as in some other localities

EXPERIMENT NO. 11—BRAN AND GLUE.

Fifty cauliflower plants were treated with a mixture of bran and glue. This was made as follows: Two pounds of hard glue dissolved by boiling in two gallons of water, to which were added two pecks of bran, and applied to the base of the plants in the same manner as the bran, Paris green and glue mixture (See Exp. No. 13). Fifty plants were left untreated for checks. Both treated and check rows were badly infested with cabbage maggot. Counts made on these plants July 26th were as follows:

	Heads	Without Heads	Missing
Treated	8	9	33
Check	9	9	32

In 1906, however, we personally obtained good results with what was practically this mixture, and also with the following:

EXPERIMENT NO. 12.—SAWDUST AND GLUE.

Fifty cauliflower plants were treated with a mixture of sawdust and glue. Two pounds of hard glue were dissolved by boiling in two gallons of water, to which two pecks of sawdust were added, and stirred until the mixture was of a consistency easily handled. One man applied this mixture to fifty plants in fifteen minutes. Check rows containing fifty plants were left untreated. This plat was badly infested with cabbage maggot. Counts made July 26th were as follows:

	Heads	Without Heads	Missing
Treated	12	7	31
Check	10	13	27

EXPERIMENT NO. 13.—BRAN, PARIS GREEN AND GLUE.

A mixture of bran, Paris green and glue was applied around the base of cauliflower plants as a protection against the maggot. The glue in this mixture was used in two different proportions—two pounds in one case, A, and three-fourths pound in the other, B, to one gallon of water.

A. Two lbs. hard glue dissolved by boiling in 1 gal. of water, stirring into the glue 2 oz. Paris green, and one peck of bran. The mixture was applied with the hands, a handful to each plant, making a circular mound about 4 inches in diameter around the plant. The amount of material used was more than enough for the 50 plants treated. These plants were treated the 18th of May. The mixture was applied at 12 noon, and by 6 p. m. was well hardened. Final counts made July 26th showed that the treatment had been a total failure. In the treated rows which contained 50 plants originally, there were at this date 8 plants with heads, 12 without heads, and 30 plants missing. The check rows started with the same number of plants, showed 32 plants with heads, 17 without and one plant dead.

B. The second mixture was applied to 40 cauliflower plants May 25th. This consisted of 12 oz. glue, dissolved in 1 gal. water, into which was stirred 2 oz. Paris green, and one peck of bran. The material was applied in the same manner as above. Final counts made July 26th showed the following results. In the treated row there were no heads, 3 plants living, and 37 plants missing. Check row contained 3 plants with heads, 16 plants without heads, and 21 plants dead.

These results of Webster's are at variance with our personal work of 1906, when, in an experiment with bran, Paris green and glue, no injury from Cabbage Maggot was evident, though these were late plants raised at a time when the maggot was not as destructive as earlier in the season. From the work cited, and from Webster's work, it is evident that the Paris green in the compound injures the plants.

EXPERIMENT No. 14—CARBOLIC ACID AND LIME.

This has been used successfully in New Jersey by Prof. J. B. Smith and was given a trial in Minnesota in 1907.

The material is prepared as follows: The lime is slaked to a thin cream; three pints of this cream to a gallon of water, to which is added a tablespoon of crude carbolic acid. This mixture was applied around the base of cauliflower plants from the time the plants were set until the flies of the second brood began to appear. An ordinary garden sprinkling can was used in applying this mixture, and about three ounces were used to each plant. The lime forms a thin crust around the stalk of the plant when it hardens, so that the maggots will not easily penetrate into the root. The theory is similar to that of the tarred felt cards, that the carbolic acid and lime mixture acts as a repellent.

Two different plants were treated with carbolic acid and lime—one on the Station grounds, and the other at Dahners' truck garden. Both plats were given eight treatments—the first three treatments made at intervals of five days, and the remainder at intervals of a week.

Fifty cauliflower plants on plat on the Station grounds were treated at these given intervals. Alternate rows were left untreated for checks. Plants were set May 17th, 1907, and the first treatment was made the 18th of May. The last treatment was made July 5th, and final counts were taken July the 20th. At that time the treated rows contained 17 heads, 18 plants without heads, and 15 plants missing. The check rows contained 14 heads, 19 plants without heads and 17 plants missing.

The cauliflower plants at Dahners' truck garden were set May 23rd, and given the first treatment with this mixture May 28th. Eight rows of 37 plants each were treated, and ten rows at one side of these left as checks. The treatments were made at the same intervals as in the preceding experiments, and the last treatment was made July 5th. Counts made on these plants the 5th of August were as follows:

	Heads	Plants Without Heads	Plants Dead
Treated (8 rows)	215	41	40
Check (10 rows)	266	62	42

Raising these figures to the same basis for comparison, that is, on the basis of ten rows, the following figures are secured:

	Heads	Plants Without Heads	Plants Dead
Treated, rows	270	50	50
Check, rows	266	62	42

The figures for both the check rows and the treated rows show practically the same results. The conclusion, then, from these figures, would be that the carbolic acid and lime treatment was not effectual.

EXPERIMENT No. 15—CARBOLIC ACID EMULSION.

Carbolic acid emulsion at the rate of one part of emulsion to thirty rts of water, was used on cauliflower plants both on Station grounds id at a truck garden. The stock solution was made as follows:
One lb. of hard soap dissolved in 1 gal. of water; 1 pt. crude carbolic cid added, and churned with a force pump until thoroly emulsified.

Fifty plants in the experimental garden were treated with carbolic mulsion. These plants were set May 17th, and the first treatment made lay 18th. The first three treatments were made at intervals of five days, nd the remainder at intervals of a week. Eight treatments were made, he last treatment was made July 5th. The emulsion was applied with a arden sprinkling can, with the perforated cap removed. Counts on this lat made July 26th were as follows:

	Heads	Without Heads	Missing
reated	1	13	36
heck	6	18	26

Ten rows of cauliflower, 37 plants to the row, were treated with the mulsion. This was in the same proportion as above—1-30. The plants were set May 21st and treated eight times, beginning the 23rd of May, and he last treatment was made July 5th. The first three treatments were at ntervals of five days, and the remainder at weekly intervals. Counts made August 5th were as follows:

	Heads	Without Heads	Missing
reated	250	82	38
heck	267	69	34

EXPERIMENT NO. 16—HELLEBORE DECOCTION.

A decoction of white hellebore was used with considerable success in he experimental garden in 1907. This decoction was made by steeping ounces of hellebore in 1 quart of water for an hour, then diluting it with vater to make 1 gallon of the decoction. It was applied with a garden prinkling can the same way as the carbolic acid and lime mixture.

Fifty cauliflower plants in our experimental garden were treated with his decoction, and fifty more plants left untreated for checks. The mixture vas applied eight times, beginning the 18th of May, and the last treatment nade July the 5th. The first three treatments were made at intervals of five lays, the remainder at weekly intervals. Counts made July 26th showed he following results:

	Heads	Plants Without Heads	Plants Dead
reated Plants	29	18	3
heck Plants	10	14	26

These rows were situated in a patch which was badly infested with abbage maggot this year, and the striking difference between treated and heck rows clearly shows the **direct benefit obtained by the use of the helle-ore decoction.**

White hellebore costs from 20c to 25c per pound at retail, so that the st of making the decoction itself is comparatively small. At 20c a pound ough of the mixture can be made to treat 1,000 plants at a cost of only 50c.

This mixture showed better comparative results than any other treatment used in the experimental work this year.

We had practically established this fact in 1906, but repeated the work in 1907 in order to be quite certain of our results.

EXPERIMENT NO 17—TARRED PAPER AND TARRED FELT CARDS.

Cards made from tarred paper and tarred "felt" were used in connection with experimental work on cabbage maggots. These cards were placed around the base of the plants, fitting up tightly against the stalk, in this way preventing the young maggots from crawling down to the roots. The odor from the cards may also act as a repellent to the flies.

The tarred paper cards were obtained from a New York dealer, and were manufactured especially for the purpose of protecting plants from this kind of injury. They are large cards—four inches in diameter, and with four cross cuts, making a star-shaped opening in the center of the card.

These cards were placed around 50 cauliflower plants set in ground badly infested with cabbage maggot this season. The plants were set May 17th, and the cards put on the following day. As a matter of fact, the assistant should have placed these cards on immediately after planting, and we supposed at the time, that such was the case. Fifty plants in alternate rows were left as checks. The final count on these rows taken July 26th was as follows:

	Heads	Without Heads	Missing
Plants with cards	4	26	20
Checks	22	23	5

This indicates a decided loss in the plants on which the cards were placed. Forty per cent of these plants died in the treated row, against only 10% in the check row, showing that the loss is probably due to the cards themselves. We obtained similar results in 1906.

Prof. M. V. Slingerland, in Bulletin 78 of the Cornell Experiment Station, 1894, advises the use of tarred paper cards, and quotes the experience of Mr. George B. Smith, of Smith Bros., Green Bay, Wis. Correspondence with Mr. Smith brought forth the following letter, under date of May 8th, 1907, of which the following is a part:

"Dear Sir:—Your letter of May 6th on hand, and as you make a mistake that a great many people do in referring to the tarred pads as paper instead of felt, I wish to call your attention to the fact that tarred paper proved to be a failure when used for this purpose. The action of the elements on the paper makes it curl up and get out of shape, but under ordinary conditions, the tarred felt will do neither.

"When Prof. Goff first sent out the tarred felt for experimental use, I think he sent some to us the first year, or certainly the second year that he sent them out, sending us about one hundred pads. I cannot say just how long ago that was, but judge it to be around eighteen years. As we were just about to set out our first lot of cabbage plants for the season, the opportunity was good to make a test. I went out to the bed and put the pads on myself, put them on in a strip through the bed, where there would be

no possible chance of saying that a swarm of flies might have gone from one side and attacked one end of the bed and leave some other part untouched. Of course, I marked the place and watched results carefully. The maggots ate almost every plant on both sides of those that had felt on and my remembrance is that the maggots destroyed only one plant of the one hundred, and that proved to be one that the pad was not on in a proper manner, possibly had been disturbed with a hoe or cultivator.

"The experiment was so absolute in its results that we at once made arrangements to use tarred felt on all of our early cabbage, and have continued using them ever since. We for some years past have been setting about 20,000 plants as soon as we could get them out after the weather was suitable for setting, and we expect to set about 30,000 within the next week or ten days, and have the pads all ready to put on them. In this locality our experience has shown that plants set later than May 24th or 25th, do not need the felt on them. Before we began using the pads, our method was to set only a small bed of cabbage for the first setting, say 1,500 or 2,000 plants. These we expected the maggots to take nearly every plant of, and then set again in about four or five days, following at intervals of two or three days with other settings. The flies seem to go to the earliest set plants and lay their eggs on them first, only destroying a few of the second planting, and hardly any of the third, but with the tarred felt, they cannot do any particular harm.

"Referring to the claim that the plants are set too low, and that the ground is too rough, and that the pads cannot be used, I will say that our soil is a good loam, and we smooth the ground a little around the plant with the hand, and put the pads on them, pressing them down carefully. I suppose you know that it does not injure a plant to break off the lower leaves if they are in the way, for they drop off of their own accord a little later. Of course, when setting very short stemmed variety of cabbage, care must be taken to set the plants in such a manner that the pads can be put on. A trifling amount of earth on top of them will not destroy their utility.

"As you refer to what Prof. Slingerland says, I presume you are familiar with the manner of cutting and using the die. Under separate cover I send you a few of the pads that are used by us and quite a number of gardeners in this locality, and I have been very much surprised that they have not come into general use throughout the country, and that some one has not gone into the business of cutting them by machinery, and placing them on the market. There is absolutely no question about their value in this locality."

A supply of cards was obtained from Mr. Smith and put around cauliflower plants. These cards were smaller than those obtained from the New York firm, and were made from what is known as one ply tarred felt. They are hexagonal in shape, and measure 2¼ inches in diameter. The plants around which these cards were placed were set May 21st, and the cards applied May 23d. Cards were applied to 5 rows, 37 plants to the row, and 10 rows at the sides of these were left for checks. Final counts made on these rows August 5th were as follows:

9

87 Plants to the Row	Heads	Plants Without Heads	Plants Missing
Cards (5 rows)	144	19	22
Check (10 rows)	249	49	72

Figuring on the basis of 10 rows gives the following comparative table:

87 Plants to the Row	Heads	Plants Without Heads	Plants Missing
Cards	288	39	44
Check	249	49	72

This shows a gain of 39 heads on the rows where cards were applied and the conditions were practically equal where plants failed to produce heads, and in the number of dead plants there is a decided difference in favor of the plants with tarred felt cards.

EXPERIMENT NO. 18—BURYING PUPARIA AT DIFFERENT DEPTHS.

This idea was suggested by the possibility that fall plowing might bury many of the cabbage maggot puparia so deep that the adult flies could not penetrate the soil and emerge the following spring.

Two series of experiments were made in order to determine whether the puparia could be buried to a depth reached by plowing so that the flies would be unable to emerge. The first series was made by Webster in the insectary during March and April. The puparia were buried in the sand in pots at depths of from one to six inches. Five puparia were placed in each pot. No flies emerged when pots were buried one and two inches deep, and only one fly emerged from each of the remaining four pots. Moisture conditions were rather unequal in the different pots, and it is probable that the pots containing puparia buried at one and two inches were too wet. When examined on May 10th the puparia in these two pots were badly decayed.

Puparia were collected from roots of cauliflower in the field and buried at depths of from one to six inches. They were placed in a wooden box set in the ground and covered with netting. This was placed out of doors near the insectary. The box was divided by six tightly fitted partitions, and the puparia buried in damp earth, making the conditions as nearly as possible the same as outside. Ten puparia were buried in each partition except in the three inch, which contained only nine. The soil become hardened through the action of rains, so that it was practically the same as the outside soil. No flies emerged from the puparia buried one inch or six inches. From the puparia buried two inches, three flies emerged; those buried three inches, one fly; four inches, two flies; and five inches, three flies.

From this it would seem that the flies were not able to penetrate through six inches of soil under conditions as nearly like outside conditions as possible.

EXPERIMENT NO. 19—VARIETY TESTS.

Holland Cabbage: Planted 50 Holland cabbage May 17th between rows of cauliflower. At the end of the season cauliflower plants were found slightly infested with cabbage maggots, but no maggots were found on the Holland

abbage. Out of the 50 plants of this variety nearly all produced solid eads. Forty sound heads were counted August 27th.

Red Cabbage: Fifty Rock Red cabbage were planted May 17th between ows of cauliflower. These plants were in soil badly infested with cabbage iaggot last year. The cauliflower was a complete failure, there being nly three heads out of the fifty plants when counted July 26th. On August 3th Mr. Ainslie found a large red cabbage which had been practically cut ff by maggots. Only 12 heads of the red cabbage (out of the 50 planted) vere found when counted August 27th, and none of these were large heads.

EXPERIMENT NO. 20—PARASITICAL AND PREDACEOUS ENEMIES.

Several hundred Pegomyia puparia were collected in the spring on the ground which was planted in cauliflower and cabbage the preceding year. This was for the purpose of rearing parasites on the imago. Mr. Webster reports on these as follows: "*Pseudoeucoila gillettei* (see Fig. 67) was the most common parasite that emerged from the collected puparia, but a number of others were also reared." Specimens of these other parasites were sent to Dr. C. T. Brues, Public Museum, Milwaukee, Wis., and determinations were made by him.

Fig. 67. *P. gillettei*, enlarged. Original.

Homotropus bicapillaris Walsh, var. *albopictus* Davis. A single specimen emerged June 6th. There is a possibility that this is not a bona fide parasite of Pegomyia, since other members of the genus are parasitic upon Syrphid larvae. Syrphid puparia may accidently have been collected along with Pegomyia puparia.

Stiboscopus sp. (?) One male specimen was reared June 2nd. This seems to be a primary parasite of Pegomya. This is probably a new specie. Females are necessary for study to be positive.

Dacnusa, n. sp. One specimen emerged June 13th. Other members of this genus are parasitic upon Agromyza and Phytomyza, and also according to Retzeberg, upon Saperda. This is evidently a primary parasite of Pegomya.

Aphacreta pegomyiae Brues. Thirteen specimens emerged in one cage on June 2nd (*A. dimidiata* Ashm. has also been reared from *Pegomya brassicae*).

Megaspilus striatipes Ashm. One specimen emerged June 10th. *M. syrphi* has been reared from *Syrphus ribis* and from *S. balteatus* according to Bouche, and there is a possibility that our species may also have been parasitic upon some Syrphid puparia collected with those of the cabbage maggot.

Isocyrtus pegomyiae Brues, Ms. One specimen emerged May 30th. This may possibly be a secondary parasite, with Pseudoeucoila as intermediate host.

Loxotropa pegomyiae Brues, Ms. Several specimens emerged June 20th. This is probably a primary parasite.

Mesocrina pegomyiae Brues. See page 192 of this report for technical descriptions of the three new species which are probably primary parasites.

The predaceous insects preying upon Cabbage Maggots were well figured and listed in our report for 1906, namely, several ground beetles (Carabidae), and particularly the red mite known as *Trombidium scabrum* Say, which sucks their eggs. We have also to add, based upon observations in 1908, the little rove beetle, *Aleochara nitida* LeConte, Fig. 69.

EXPERIMENT NO. 21—LENGTH OF LIFE OF PSEUDOEUCOILA.

Three Pseudoeucoila were confined in a small vial April 30th, and lived until May 10th without being disturbed. Two were dead on that date, and the third apparently dying. From this it seems evident that Pseudoeucoila can live at least nine or ten days, and probably much longer than that under natural conditions.

THE EMERGENCE OF THE CABBAGE MAGGOT FLY AND THAT OF ITS PRINCIPAL PARASITE (PSEUDOEUCOILA GILLETTEI ASHM.) COMPARED.

We use the term "principal parasite" in connection with *P. gillettei* because it appears to have been the one most abundantly reared in the insectary. We personally found it in the burrows of cabbage maggots in the field in 1906, and reared it from puparia.

This parasite is a small four-winged fly about one-tenth of an inch in length, shiny black in color. The antennae are slightly longer than the body, and the legs are brown. It belongs to the Cynipidae, a family of insects, most of which form galls, but containing a few parasitic forms.

The parasites spend the winter within the puparia of the cabbage maggots, emerging from these in the spring a short time after the cabbage flies appear. The first appearance of Pseudoeucoila in our cages was April 26th, when Webster found a single specimen which had emerged from Pegomya puparia collected March 26th. The material was kept in a warm room at the insectary, which fact will account for the early date of emergence. This lot of puparia was gathered among cabbage and cauliflower stalks in a garden at St. Anthony Park. A total of 46 per cent of these puparia were parasitized by *Pseudoeucoila*. Specimens of the parasite continued to appear in insectary cages through the entire season, three emerging the latter part of the summer from puparia gathered in the spring. It has been observed before by Prof. Slingerland that a part of the puparia of the first brood did not give forth flies until late in the season. This peculiar retardation of development was also found to be true in the case of *Pseudoeucoila gillettei.*

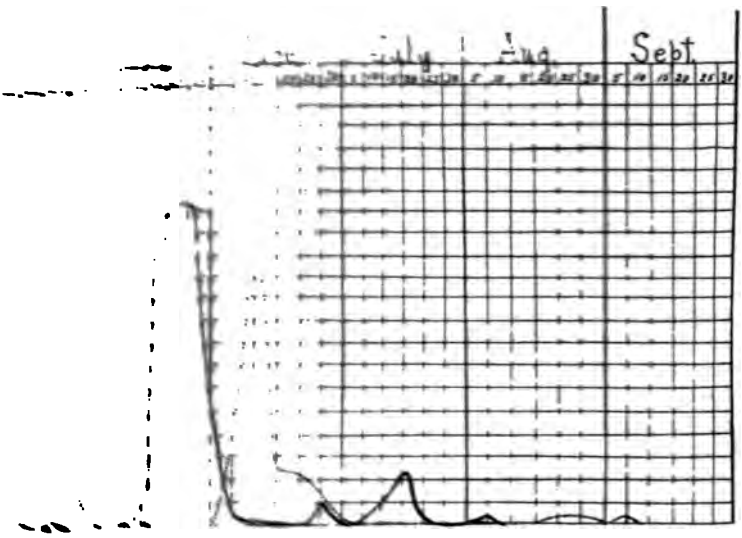
From Pegomya puparia gathered May 9th Dillon reared two Pseudoeucoila adults, one emerging August 17th, and the other September 2nd. A third specimen was reared August 24th from puparia gathered the 14th of May. The accompanying table shows dates of emergence of both Pegomya and Pseudoeucoila. The figures represent the actual number of specimens reared for five days of each month. The collections of puparia were made in the spring, so that the table represents only one brood of either species. The earlier dates for both insects are emergence from cages in the heated insectary room, and for that reason would be ahead of the time that the fly and parasites appear outside. It will be noticed that the cabbage flies appeared first, followed about two weeks later by Pseudoeucoila. The largest number of flies of the first brood emerged from May 15th to May 30th, while the greater number of Pseudoeucoila emerged from June 1st to June 25th. The intervening time between the emergence of the two insects is sufficiently long for the flies to deposit their eggs, and the young hatch and become partly grown before Pseudoeucoila appears.

	April						May						June						July						August						Sept.		
	5	10	15	20	25	30	5	10	15	20	25	30	5	10	15	20	25	30	5	10	15	20	25	30	5	10	15	20	25	30	5	10	15
Pegomya		1	3	2	2				4	66	74	27	2	1	1		5		2	5	12	1			1								
Pseudoeucoila						7		1	1				24	55	12	11	7											1	1		1		

A total of 209 Pegomya of the first brood emerged during the season, and 121 of the Pseudoeucoila. Some of the puparia did not give forth either flies or parasites, and we have no definite record of these. Adding these two figures gives 330 puparia, and taking the percentage of Pseudoeucoila from this total gives 36.6% or nearly 37%. If those puparia from which nothing emerged had been counted doubtless the percentage would be somewhat lower.

Number of Broods. It is probable that the number of broods correspond closely with those of Pegomyia. No attempt was made to breed the parasite on maggots, and so we have no accurate data on that point.

With the above facts before us it is easy to construct a diagram which shows at a glance when the cabbage maggot fly was most abundant, how near its parasite approached it in numbers, and how the latter follows in its appearance that of its host. These data are of value to planters as showing approximately at what dates in ordinary seasons the fly is to be looked for in greatest numbers.



... between emergence of Cabbage Maggot Fly ... comparative abundance. R. L. Webster.

... CABBAGE MAGGOT IN 1908.

... directed more particularly toward find- ... from the attacks of this

EXPERIMENT NO. 1.

... planted. When plants were ... Two rows with milk ... of lime and oil of cloves, four ... See Experiment No. 2 for ... was repeated.

... No effect for any treatment.

EXPERIMENT NO. 2.

... each one thirty-one feet long ... Milk of lime (2 lbs. to 3 ... 3 gal's.), and milk of lime ... to 1 gal.).

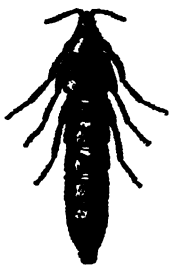


Fig. 69. *Aleochara nitida* LeC., an enemy of the Cabbage Maggot, enlarged. Original.

Results: Untreated pants produced the greater number of good radishes, apparently on account of the injury to foliage by the above treatment.

EXPERIMENT NO. 3.

Thirty sixteen-foot rows of French Breakfast radishes planted June 25th, and the rows as soon as planted, were treated with lime solution alone (see above); with lime solution and oil of cloves (see above); with lime solution and crude carbolic acid (see above); with the lime solution and oil of tar (1 oz. to 3 gals.); and with the lime solution and oil of lemon (1 oz. to 3 gals.). Two quarts of the solution was used upon each row, and five rows were left untreated as a check. The oils in each experiment were cut with alcohol before mixing, and the emulsions were made by churning with a small force pump.

Results: On July 2nd the radishes were up, and were given a second treatment similar to the first application. On August 5th the radishes were pulled and counted. Maggots had seriously injured the rows treated with lime and oil of lemon; the rows treated with lime and oil of cloves were entirely free from maggot attack, as were, practically, those treated with lime and oil of tar and with lime and carbolic acid. the latter showing only .01% injury, as per the accompanying table.

Row	Good	Marked	Total	Per cent Marked	Plot and Treatment
1	185	13	198	.....	
2	160	39	199	.....	
3	160	34	194	.....	No. 1 Check
4	150	46	196	.....	
5	150	41	191	.....	
	805	173	978	17%	
6	199	11	210	.....	
7	175	7	182	.....	
8	161	24	195	.....	No. 2
9	116	64	180	.....	Lime
10	133	48	183	.....	
	786	154	940	16%	
11	115	56	171	.....	
12	144	42	186	.....	
13	142	32	174	.....	No. 3
14	185	16	201	.....	Lime and
15	154	35	189	.....	Oil of Lemon
	740	181	891	20%	
16	165	2	167	.....	
17	175	4	179	.....	
18	185	..	185	.....	No. 4
19	195	2	197	.....	Lime and
20	204	8	212	.....	Oil of Tar
	294	16	940	.02%	

Row	Good	Marked	Total	Per cent Marked	Plot Trea
21	185	....	....	.....	
22	200	....	....	.....	
23	200	....	....	.....	No. 5
24	195	....	....	.....	Lime an
25	240	....	....	.....	Oil of Cl
	1020	....	....	.....	
26	180	....	....	.....	
27	167	....	....	.....	
28	175	2	....	.....	No. 6
29	134	2	....	.....	Lime an
30	170	2	....	.....	Carbolic
	826	9	....	.01%	

EXPERIMENT NO. 4.—HELLEBORE DECOCTIO

On June 28th planted eight rows of radishes sixteen feet lo 9th these were treated with hellebore decoction (4 oz. steeped i water), and repeated on July 23rd. Pulled and counted on July 2 advantage in the use of this decoction was apparent.

EXPERIMENT NO. 5—TOBACCO DUST.

On June 25th eight sixteen-foot rows of radishes planted. Tob was scattered thickly in the rows before sowing the seed. July 28t pulled and counted. Seven per cent of the roots were marked gots. This treatment made a good showing compared with the cl and might have done even better possibly if there had been on treatments after the radishes were up, omitting the first treatm sowing. We have found tobacco to be an excellent fertilizer for

EXPERIMENT NO. 6—MISCELLANEOUS.

On June 5th twelve rows of radishes were planted, different s being planted with the seed as follows:

Two rows—Tobacco Dust.

Two rows—Carbolic Acid and Milk of Lime.

Two rows—Sulphur.

Two rows—Check.

Two rows—Hellebore.

Two rows—Salt (to test a statement of a correspondent).

As might have been expected, the plants were injured by t ment, and in the following order: Salt most injurious, then carb tobacco dust, hellebore, sulphur. In Experiment No. 5, however dust was used with success. This difference in result may have be abundant rainfall at a time when the seedling could be easily inju check rows showed so little injury by maggots at this date that th ment loses force in consequence.

EXPERIMENT NO. 7—MISCELLANEOUS.

Sixteen rows of radishes planted June 5th, and with the placed the following: One row salt (to test statement of corres one row tobacco dust; one row powdered hellebore; the remain

left as checks. These were repeated as applications to the plants on June 10th and again on June 24th, and again July 3rd. Radishes pulled and examined July 16th. None of the above treatments were distinctly successful, although the hellebore showed some advantage over the others.

EXPERIMENT NO. 8—MISCELLANEOUS.

On July 24th sixteen rows of radishes planted:

Four rows left untreated as check.

Four rows treated with hellebore decoction on Aug. 1, 10 and 26.

Four rows sulphur planted with seed.

Four rows treated with milk of lime and carbolic acid on Aug. 1, 10 and 26.

On September 8th radishes pulled and examined. Decidedly fewer maggot marks on those treated with hellebore and those treated with carbolic-lime than on check plants, but the treatment in each case appeared to affect the growth of the plants.

EXPERIMENT NO. 9.—MISCELLANEOUS.

On July 24th twelve sixteen-foot rows planted. Treated on August 3rd, 10th and 26th as follows:

Four rows with tobacco decoction.

Four rows untreated as checks.

Four rows with hellebore decoction.

On September 8 radishes pulled. No definite results.

EXPERIMENT NO. 10—HELLEBORE DECOCTION.

Eighteen sixteen-foot rows planted July 24th. Four rows untreated; four rows treated with hellebore decoction as follows: August 10th and August 26th. On September 9th radishes pulled and examined. Treated rows showed 50% gain in unmarked radishes over the untreated. In other words, there were only half as many marked roots in the treated rows as in the untreated.

EXPERIMENT NO. 11—A COMPARISON OF VARIETIES TO TEST THEIR SUSCEPTIBILITY TO MAGGOT ATTACK.

Twenty-eight rows of radishes planted June 28th as follows:

1 and 2 two rows—Early Golden Yellow.
3 and 4 two rows—Early Round Deep Scarlet.
5 and 6 two rows—Early Scarlet Turnip, White.
7 and 8 two rows—California Main White China (winter).
9 and 10 two rows—Improved Chaitrer.
11 and 12 two rows—Scarlet China.
13 and 14 two rows—Icicle.
15 and 16 two rows—Round Black Spanish.
17 and 18 two rows—Early White Giant.
19 and 20 two rows—Half Long Black Winter.
21 and 22 two rows—White Strasburg.
23 and 24 two rows—Early Scarlet Globe.
25 and 26 two rows—Early Scarlet Globe Turnip Root.
27 and 28 two rows—Long Red Ear, Short Top.

[illegible] rows 9 and 10 were washed out by rains, [illegible]ows 14 and 22. All rows were thinned and weeded and examined August 6th. The winter radishes in row [illegible] had not matured.

[illegible] Early Golden Yellow, rows 1 and 2, suffered the [illegible]ck, next in order came Icicle (rows 13 and 14), and [illegible]ap White (rows 5 and 6). The following table sh[illegible]ld.

[illegible]ood	Marked	Total	Per Cent Ma
126	27	153	
108	54	162	
	81	315	25 [illegible]%
178	10	188	
181	14	195	
	24	383	.06%
168	25	183	
150	21	171	
	46	354	13%
115	5	120	
130		130	
		250	.02%
108	4	112	
120	2	122	
	6	234	.03%
131	23	154	
75	28	106	
	51	260	20%
140	2	142	
140	6	146	
	8	288	.03%
169	1	169	
178	9	187	
	10	356	.03%
178		178	
180		180	
		358	0%
152	8	160	
169	4	152	
	12	317	.04%

Row	Good	Marked	Total	Per Cent Marked
23	160	1	161	
24	183	6	189	
		8	350	.03%
25	135	6	141	
26	125	10	135	
		16	276	.06%
27	145	15	160	
28	103	8	111	
		23	271	.08%

EXPERIMENT NO. 12 TRANSPLANTING AND DIPPING ROOTS.

This experiment was performed purely from a scientific interest in getting results. Naturally the method never could be used in practice.

On June 13th five rows (25 plants each) were set out, the roots being first dipped as here indicated:

Row 1—Tobacco Dust.

Row 2—Lime.

Row 3—Sulphur.

Row 4—Untreated.

Row 5—Carbolic Lime.

Plants in 1, 2 and 3 were dipped in water first to make the above substances adhere. None of the treated plants were noticeably injured by maggots, but the lime and the carbolic lime injured the plants.

Summarizing from work of 1908 and from previous experiments:

Radishes grown in the open are apparently benefited by several applications of hellebore decoction (4 oz. of white hellebore steeped in 2 gals. of water) applied with a watering pot, first when plants are one and one-half inches high, and three or four later applications at five days' intervals; or by the use of tobacco dust with equal frequency in the same way. Or by the use of milk of lime with either oil of tar, oil of cloves, or crude carbolic acid as above. These last three are not to be regarded as practical when more simple remedies are available.

We have obtained good results in our own garden by the use of tobacco decoction (about 1½ lbs. of stems steeped in 4 gals. water), applied frequently with a watering pot.

Oil of cloves costs about 20c per oz., and oil of tar about 20c per pint.

TWO GRAPE INSECTS.

GRAPE FLEA BEETLE.

Haltica chalybea Ill.

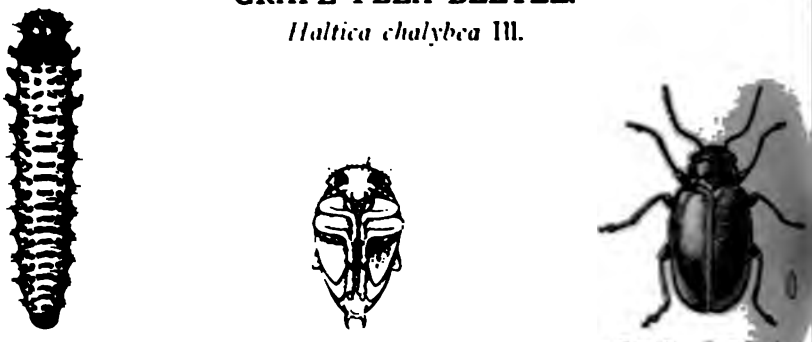


Fig. 70. Larva, pupa and imago, with egg of Grape-vine Flea Beetle. Original.

This little beetle is common enough in this state, affecting, however, the wild grape in preference to cultivated varieties. The writer has the end of his porch at Lake Minnetonka covered with wild grape, which he has purposely allowed to be attacked by this pest. For two seasons, as long as the present owner has been in possession, the leaves of the wild vine have been riddled, while a dozen specimens of cultivated varieties not forty feet away are untouched. It is possible that the custom of covering cultivated grapes with soil in the late fall is, in part at least, the cause of their immunity.

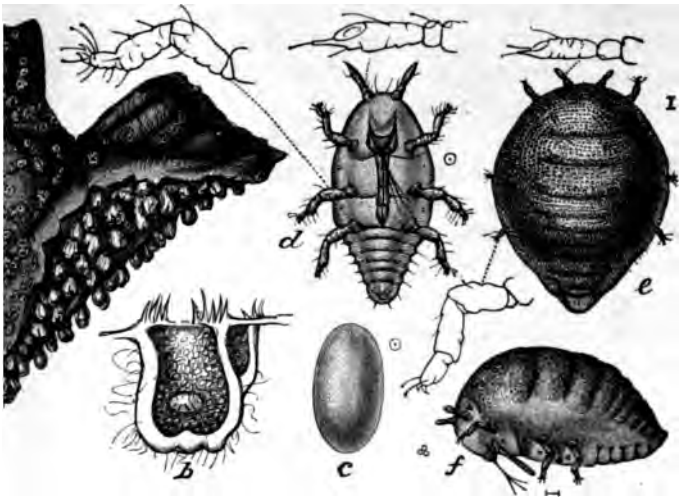
The Grape Flea Beetle is about one-eighth of an inch long, steel blue, or purplish blue or greenish, and feeds in both the adult and larval stages on the grape leaf, frequently beginning its destructive work when the vine is in bud. It lays clusters of yellow eggs on the under side of the leaf, which shortly hatch into darkish colored larvæ, feeding in colonies, and filling the leaves with holes.

It takes almost three weeks for the larva to become full grown, at which time it is about one-third of an inch long, with a black head, and with a number of shining black dots on each segment of the body. When full grown they burrow a short distance into the soil, the beetle emerging in two or three weeks. Like all flea beetles, the thighs of the hind legs are well developed for jumping, and this flea-like habit gives rise to its name. In the fall the adult beetles conceal themselves for the winter under rubbish or in the soil close to the plant affected.

Remedies: *Clean cultivation; allowing no leaves or other rubbish to remain near the vines. Cultivation of the soil about the plants. Spraying of leaves with arsenical's. Bordeaux mixture is said to act as an effective repellant.*

THE GRAPE PHYLLOXERA.

Phylloxera vastatrix Planch



ıpe Phylloxera, *a*, leaf with galls; *b*, sections of gall showing mother ıg clustered about her; *c*, egg; *d*, larva; *e*, adult female; *f*, same from ıl size, rest much enlarged. After Marlatt, Bur. Ent., U. S. D. A.

ıs of both cultivated and wild grape leaves infested with re sent this department during the summer of 1908. The :s are characterized by little wart-like growths on their :re is, however, another form distinct from the leaf form, on the roots, where it works unseen, and in cases of bad sure to kill the vine. It is the root form which is to be the leaf form. The former makes characteristic swellings he smaller roots, extending its work to the larger roots, the same.

infestation of the roots is indicated above the ground by pearance of the vine, a yellowing of the leaves, lack of It is claimed that when the leaf form is very abundant ı is not in injurious numbers on the same vine, and vice undance of the root form is not accompanied by an the leaf form.

oduction of this louse, for it is a form of plant louse, re- general way that of other aphids; sexual females in the gs which winter over, and give rise to the stem mother . The young louse, upon hatching, feeds upon the leaf, ısing a depression in the leaf, the insect finally becoming

inclosed in a gall-like growth on the under side of the leaf. This louse, which is a wingless female, shortly after dies, leaving the gall filled with her eggs. In about a week or more these eggs hatch, and the young lice migrate, each one forming a new gall. There are several generations, the fall produced young crawling to the roots and hibernating in that location. In the spring they attack the root, thus becoming the "root form." In the following autumn winged forms are produced on the roots, and crawling up through cracks and crevices in the soil, fly to other vines, laying their eggs thereon and dying. The eggs thus laid are of two sizes, large and small, the larger producing females, the smaller males. After mating the female lays eggs which last through the winter and give rise to another generation in the spring.

In considering treatment for this pest, it is to be noted that American vines are not troubled to the extent that European vines are, because, as one writer claims, there is a thicker and denser bark on the American roots; yet the Delaware is said to be very susceptible, as are the Isabella and Catawba. The Concord is subject to attack, though rarely to a serious extent. This insect may never be, in Minnesota, the serious pest it is in the wine-making countries of Europe, where it has been known for a long time. Should it become so it would call for special treatment and energetic work on the part of our fruit growers.

BUFFALO TREE HOPPERS.

before has there been so much complaint of this common pest as in 1908. Were it not for the fact that many of our ; and nurserymen have mistaken the work of the pest for the ıail, which it somewhat resembles, the complaints would more numerous than they have been. If one notices on trees ıg apple orchard an insect or "bug" a little over a half inch a formidable looking head furnished with two horn-like ;, one on each side, he may be reasonably sure it is a Buffalo per of either one or the other variety. Or should he ob- ı branches or trunk of his trees pit-like depressions, look- ail marks, or small slits in line, he may well ascribe them k of these insects. These punctures are made by the female ıer eggs, and apart from the fact that these insects suck the the tree and thus impoverish it, it is these punctures that ularly injurious, since they not only weaken a branch so easily broken by the wind, but they also open the way for ; of other insects, borers, for example, and for disease.

ı *bubalus* Fab., is green with whitish and yellowish markings. l upon our apple trees during the entire summer. A single y deposit, in the punctures above referred to, over a hundred egg laying takes place during the late summer and early se eggs hatch in the spring, the young not looking like the having a body which is more or less spiny. The other close- ee hopper whose work we have noted in this state, is *Cercsa* tch, with habits practically like the preceding.

dies: *Pruning where possible in the late fall or very early ore hatching of eggs, and the destruction of twigs showing*

The application of a repellant and killing wash to trunk branches at intervals during the summer. Clean cultivation hard, doing away with other growths than fruit trees, which e as food for the pest.

ellant and killing wash might be well made by using a strong ecoction in kerosene emulsion, white wash to which tobacco ed sulphur or both has been added, etc.

THE STRAWBERRY ROOT LOUSE.

Aphis forbesi Weed.

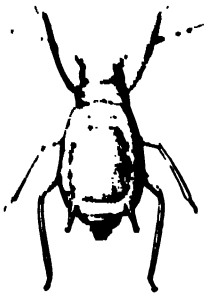


Fig. 14. Strawberry Root Louse. Original.

The first and only complaint of this insect, which may be a serious obstacle in the way of strawberry raisers, came from Stillwater in July, 1908. A visit to that locality disclosed its presence on about nine rows containing 1,000 plants on the place of Superintendent Larson. Six of these rows were Warfields, two Senator Dunlaps, and one Lovett. The Warfields were originally purchased in 1907 from a grower in Michigan, and these vines after planting were noticed by Mr. Larson to be unhealthy in appearance, as were those in the older bed (mostly Senator Dunlap) immediately around the Warfields. The nine rows infested with the louse were set out in the spring of 1908, and for the most part looked poorly, with foliage not well developed at the time of our visit July 28th.

Mr. Larson reported that two years previous a grower four miles from him was troubled in the same way, but that his neighbors thought the injury was caused by ants. It is possible and probable that the Strawberry Root Louse was the guilty party, and that the ants collected in abundance about the affected plants at Mr. Larson's were attendant upon the lice, for, curiously enough, ants of the genus *Lasius* care for these lice when young, carrying them from the leaves to the roots. According to Prof. Sanderson "the ants are solely responsible for carrying the lice to the roots, as up to the time of their disappearance no lice are to be found upon the roots. * *

"As the plant becomes overcrowded the aphids are carried to the fibrous roots and in this way the ants are almost entirely responsible for the spread of the aphids throughout a bed, as well as for carrying them to the roots of the plants."

Eggs are laid in the fall upon the stems and leaves and hatch early in the spring. There are apparently several broods, and they may be spread not only from plant to plant through the agency of ants, but from one field to another at some distance away by means of

winged individuals which appear from time to time during the summer. Fertile females and males appear in the fall, and eggs are laid as above indicated.

Remedies: *Plant uninfested vines on ground known to be free of the pest. Never use plants from an infested field. Do not use land previously infested until it has lain fallow for at least two years, or has been planted for two years with some crop other than corn or cucubits, since ants also attend lice on the roots of such plants. A purchaser finding plants infested, as shown by the presence of an insect in some stage on leaves or roots, should either refuse to accept them, or should immerse them for from two to three minutes in kerosene emulsion, one part to twelve parts of water, washing them thoroughly afterwards with pure water. Dipping them in tobacco solution will also kill the lice.*

If any Minnesota grower finds his plants dying off, or producing poorly, and notes an abundance of ants in the field, it would be well for him to examine the roots of some of the plants, and if lice are found thereon, to communicate with the Entomologist at the Experiment Station.

These lice do not apparently occur on other plants, according to Professor Sanderson, who has done considerable work with them. Mr. Larson sent us weeds in September, which were growing next to his strawberries, loaded with lice which he supposed were the same species, but which proved to be *Aphis rumicis* and in no way threatening the vines.

BLACK FLIES, BUFFALO GNATS, TURKEY GNATS.

Although these insects have been discussed in previous reports from this department there have been so many complaints in 1907 and particularly in 1908, and so much letter writing has been caused in consequence that it appears desirable to include here a few statements regarding the pest, and to suggest certain remedial measures which will to an extent afford relief.

This insect breeds in running water, and localities in this state which are so blessed will also always be troubled to a greater or less extent every year with this annoying and seriously injurious enemy to man and stock.

This year from some localities within the state came reports of poultry being killed, and one excited and possibly imaginative editor published a statement that a colt's death was due to their attacks. We quote from our report of 1905:

"SIMULIDAE, Black Flies, Buffalo Gnats: These minute flies belonging to the single genus, *Simulium*, are always more or less troublesome in summer to both stock and man in certain localities. Only the females "bite" but many of us can bear witness that each female can do enough mischief for two, and many a would-be prospector, surveyor or fisherman has returned in disgust from the woods, vanquished by the persevering hosts. A clot of blood generally marks the point of the creature's attack. Swarms of them frequently annoy horses during spring plowing, and when, as sometimes occurs, they attack stock in enormous numbers, serious loss is occasioned. Cloudy weather discourages them, for, like the chinch bug, they want warm sunshine.

"The perfect flies, that is, the imagoes, or adult insects, are about one-eighth of an inch long, more or less downy or velvety, a 'humped' thorax and the short antennæ consisting of eleven joints. They breed in running water, hence they are particularly abundant in the northern part of Minnesota, where, for them, ideal summer conditions exist. In the northern part of Minnesota in ordinary seasons they begin to be troublesome a little before the first of June. Oil of citronella, used as for mosquitoes, is effective as long as the skin is moist with the same.

"We have found *S. venustum* fairly abundant and annoying stock in this state about the last of May (27th to 30th)."

Remedies: For present use the various compounds usually reported to. Personal experience leads us to regard oil of citronella undiluted as excellent as long as the skin is kept moist with same. Animals with rough hair, i.e., winter coat not shed, suffer more than those whose skin is smooth. Horses and cattle in darkened stables are not attacked. For a working team in the field fish oil (or fish oil three parts and kerosene one part) is a good repellant, applied about once a day. Do not use machine oil. *Cheese cloth screens are effective.*

The Long Meadow Gun Club, at their grounds on the Minnesota River, lost, in the spring of 1908, nearly two hundred young ducklings within three weeks, apparently from the attacks of this pest, for when the duck runs were screened in completely by the use of cheese cloth the mortality was much less.

In using oil of citronella care must be taken not to allow it to touch the eyes.

DESTRUCTION OF LAWNS BY THE WHITE GRUB.

Lachnosterna rugosa and *fusca.*

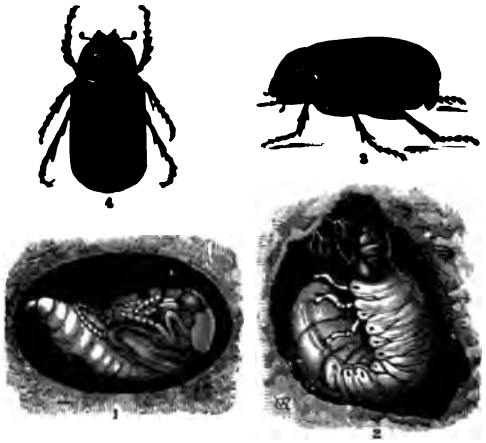


Fig. 73. "White Grubs," *L. fusca*, larva, pupa and beetle. After Riley.

Never before has this pest been so troublesome as in 1908. Complaints have been numerous and frequent.

The grub is the larva of a robust brown beetle, commonly spoken of as "June Bug," or May Beetle, the big, clumsy fellow which buzzes into open windows and about the lighted lamp in early summer. This insect, shown in our illustration, belongs to the genus *Lachnosterna,* and the species we have commonly with us appears to be pretty evenly divided between *fusca* and *rugosa.* Not only do the young of these beetles work havoc on lawns, but the adults are active at night, they work "while you sleep," feeding upon the leaves of fruit and shade trees, and capable, when very numerous, of stripping the trees of their foliage. Eggs are laid amongst the roots of grass, and the young grubs when hatched begin to feed upon the rootlets, sometimes killing patches many square feet in extent, and leaving the grass brown and dead, easily separated from the ground below; in fact, it can be lifted and rolled up with the hands. It takes two years, or longer, it is believed, for this larva or grub to become mature, hence a lawn laid waste in 1908 would not, if all the grubs which caused the injury were full grown at that

:, show any further injury from this source until 1910. In other ds, this year's grubs would change to beetles next spring, when ing and egg-laying would take place; the young hatching from eggs in the spring of 1909 would not be large enough to work appre- ble injury until the summer of 1910.

To be effective, any treatment against this pest must be begun as n as the first signs of injury to the lawn are observed. To wait until grass is brown and dead is like shutting the door after the horse tolen. The most acceptable treatment at this date appears to con- of copious watering of the lawn where possible, accompanied by the of some artificial fertilizer, like nitrate of soda (from 250 to 350 nds to the acre), thus enabling the lawn by vigorous growth to p ahead of the grub. One should at least resort, in such emergency, abundant watering where possible, even though the fertilizer is not lied. J. B. Smith, State Entomologist of New Jersey, claims to e obtained relief by the liberal use of ground tobacco stems scat- d broadcast and liberally over an affected lawn, followed by copious ering. He states that grubs disappeared after this treatment. This gests, naturally, the frequent sprinkling of lawns with a tobacco oction. Evidently, this would have to be quite strong and used erously. These and other remedies will be given a thorough trial at next appearance of this pest on lawns. We have killed them by use of bisulphide of carbon without injuring the grass, but the cess is a slow one and impracticable where large areas are involved. ver is not seriously affected by this insect.

After the lawn is dead in patches nothing remains for the owner lo but to re-sod or re-seed. In addition to complaints through the il this season, we have noted their destructive work on various kways of the Twin Cities, on golf links and on private lawns in the ntry. Lakewood Cemetery has suffered severely, and at this writ- workmen are engaged repairing the lawns injured there. Lantern ps, three dozen in number, were placed in various parts of this ceme- y for two successive years, 1906 and 1907, and many hundreds of tles captured, but the fact that in spite of these traps the lawns suf- ed this year would indicate that the captured specimens were either gely males, or females which had already laid their eggs, or both. bins greatly aid in the extermination of the White Grub, and may quently be seen pulling them from under the dead grass. They uld be encouraged in this good work. Moles and shrews eat them ! we believe that skunks are also fond of them. If the grubs should carefully removed and destroyed when brownish patches are first

observed in the lawn their injurious work is at once stopped. They will be found just below the sod if they are responsible for its condition.

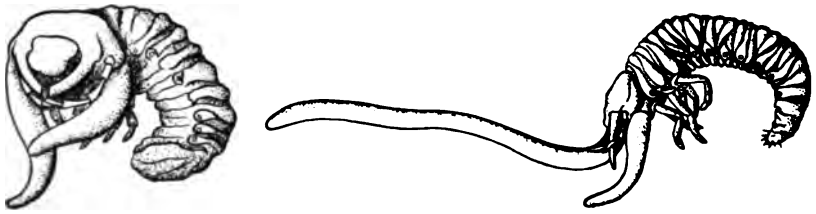
In this connection the following letter from E. J. Phelps, of Minneapolis, under date of Oct. 13, 1908, is of interest:

"Replying to your favor of the ninth, would say that in the summer of 1899 my lawn at the Lake was ruined for that season by the grub to which you refer. I do not remember now that we took any means to destroy them excepting to have the turf taken up and the grubs picked up by hand and put in a pail and destroyed. I should imagine that we gathered one or two bushels of them.

"As I remember it, we were not troubled the next year and I have seen no trace of them since. I understand that a number of the places about the Lake were injured this year, but so far our immediate neighborhood is fortunate enough to escape their work.

"I have not used any fertilizer upon the lawn, but have almost every year drawn a good many loads of black dirt which has been scattered over it, and in this way have kept the lawn in good condition.

"This trouble referred to in 1899 I did not notice before departing for the East the latter part of June. When I returned about a month later the sod looked white and burnt out and I at first supposed that it was due to inattention on the part of the gardener, but later discovered the real cause, as it was very easy to kick the turf up or to pick it up and lay it back in quite large sections or strips, leaving the colony of grubs exposed beneath."



Figs. 74 and 75. Larvae of *Lachnosterna* attacked by fungus. Original.

Figs. 74 and 75 do not represent fossil monsters of prehistoric times, but are two white grubs attacked and killed by a fungus growth (seen growing from near the head of the grub in each case) sent the entomologist by Mr. M. C. Clark, of Nymore, Minn., with the statement that one-half of his potato crop had been eaten by this pest.

PRELIMINARY REPORT UPON WORK WITH THE STALK BORERS IN MINNESOTA.

Papaipema species.

These disgusting pests, "worms" they would be called by gardeners, bore into and ruin many of our choice flowering plants, and also work in the stalks of barley, corn, oats, tomatoes, etc. They have been found boring in Dahlia, Hollyhock, Golden Glow, Gallardia, Phlox, Delphinium, Aster, Daisy, Peony, Rose and Sunflower, and have been referred to frequently in previous reports from this department, detailed directions being given in the annual report for 1906, for combating them during the summer, by removal and by the use of carbon bisulphide. They are so common and so destructive that they seem worthy of careful work on the part of the Entomological Division, particularly since the life histories of the various species have not been worked out for this part of the country.

The presence of the larva of *Papaipema* may be detected in such plants as Golden Glow, Peony and Hollyhock by a noticeable wilting of the top of the plant, often followed by the portion of the stalk above the entrance hole breaking down. A careful search around the bases of such partially wilted plants, or an examination of the stalk itself will usually reveal a quantity of caterpillar excrement. This having been found, it is an easy matter to locate the entrance hole of the caterpillar. Burdock and Giant Bur-elder having thick stalks, show but little wilting, but the presence of a caterpillar in a stalk of these plants is usually indicated by the stalk being somewhat swollen, and the caterpillar excrement is always present. Stalks of these plants never break over after being attacked, as do the stalks of Golden Glow and other equally delicate growths.

Golden Glow and such small stalked plants rarely, if ever, harbor more than one larva. One stalk is usually sufficient for the development of a single caterpillar. Burdock, on the other hand, often has more than one caterpillar in a single stalk. The larvæ of *cataphracta* and *nitela* work in the center of the main stalks of their food plants, and they often work out from the main stalks into the branches, and sometimes enter the branches first and work into the main stalk later.

For the purpose of getting all the information possible along these lines, and of making a study of the life histories of the various species of this genus, upon which treatment of plants largely depends, Dr.

Franklin, in charge of our insectary and field work, was given t problem, and took up the work upon *Papaipema* July 3rd, 19 During the season he has conducted sixty-three different experime in laboratory and in our experimental garden on this genus. He l reared and determined the following species:

Fig. 76. Stalk of Giant Bur-elder showing cluster of eggs of *P. nitela* at point indicated by line. Original.

P. nitela Gn., and the variety *nebris*;* *P. furcata* Smith, and other common species, which, to all appearances, is *P. cataphr* Grote. Still another species, not yet determined, reared from Burd appears to be entirely different from the above three. A larva this last species pupated August 13th, and the moth issued Septem 9th.

*If the rules of zoological nomenclature were strictly followed, *nebris* should t ferred to as the species, and *nitela* as the variety. J. B. Smith, however, claims tha relationship between the two forms is better expressed by treating *nitela* as the spe and we have, therefore, followed the established precedent, leaving this chan others.

P. nitela and the variety *nebris* were found working in plants at very beginning of the investigations, and their larvæ were dis-ered as late as August 18th. The first pupa was found August 8th, l no larvæ were found after August 18th. The first moth of this cies emerged August 31; the last moth emerged September 17th. e length of the pupal stage, as shown by the records of several bred cimens is about twenty-two days (from nineteen to twenty-five) he average.

Fig. 77. The same egg cluster as shown in preceding figure enlarged 9½ times. Original.

Eggs were laid in a breeding cage by an unmated female on September 7th. Several moths were placed in a breeding cage over a giant ar-elder plant, and presumably mated. These, for the most part ere of the variety *nebris*, though one or two were typical *nitela*.

Eggs were laid in two clusters or masses on the base of the plant lks, between one and two inches from the ground, there being be-een fifty and sixty eggs in each mass. Eggs were also scattered in

considerable numbers on the sides of the cage, and a few were laid on the ground. Some were also found on a couple of tin boxes left under the cage, and on some old pupa cases. We figure these egg clusters in the accompanying photograph. They were almost pearly white in color when fresh, but became brownish gray in a few days. They are round in shape, slightly flattened, with alternating rediating ridges and depressions on the surface. These ridges are cut somewhat by concentric lines. The eggs measure about 5-10 mm. in diameter.

The larvæ pupate, for the most part, in their burrows in the stalks of food plants. *P. nitela nitela* was reared from Giant Bur-elder, Peony (one specimen only from Peony), and Hemp. Larvæ of this species were also found working in common ragweed, *Ambrosia artemisiaefolia*, Corn, Tomato and Lamb's Quarter, while *nebris* was reared from Burdock, Giant Ragweed (*Ambrosia trifida*), Giant Bur-elder (*Iva xanthiifolia*). Giant Bur-elder was found to be by far the most commonly and most heavily infested plant. Next to that came Giant Ragweed. Hemp and Burdock, while somewhat infested, could not be said to be heavily so. All the other plants were only occasionally infested.

Figs. 78 and 79. Egg and adult of *P. nitela*. Original.

A considerable number of parasites were reared. It is evident that this species suffers very heavily from parasitism, mostly from *Tachina* flies. Dr. Franklin estimates that 70 per cent. of larvæ were destroyed by parasites during the season.

Papaipema cataphracta Grote: What is supposed to be this species has been bred within the past season from Burdock, Golden Glow, Thistle, Hemp, and one larva which was not reared, but which appears to belong to this species, was found in Tansy, and one in Sumac. Burdock is the principal food for the species. Hardly a single Burdock plant, examined during the month of August, was found to be free from infestation. One plant was found to harbor five larvæ and

iree pupæ in one stalk, one of these being two feet and nine inches rom the ground. Hemp and Golden Glow were also badly infested, ut much less so than Burdock. A single specimen was found in Thistle. Golden Glow was found affected at the very beginning of the season's work (July 3rd). This species was found working as late as August 24th. The first pupa was found on August 5th, and no larvæ were found after August 24th. The last one pupated in captivity on that date. The first moth emerged on September 9th, three issuing on that day. The last moth which was reared emerged September 22d.

Over half of the pupæ which we had of this species died, apparently because they did not have sufficient moisture to carry them through the process of emergence from the pupal stage. Nearly all of them were found as dead moths in the pupal cases at the time of the closing of the experiments. This species, one would assume, therefore, needs more moisture in the pupal stage than does *P. nitela*, with which we had no such experience, rearing them successfully under exactly similar conditions. The length of the pupal stage of the species was shown by the records of several specimens, as about twenty-two days on the average. We failed to get eggs from a moth of this species. The larvæ always pupate in their burrows made in the stalks of their food plants. This form appears to be as heavily parasitized as *P. nitela*, *Tachina* flies being among the most important parasites.

Papaipema furcata Smith: Larvæ of this species, boring in the new growth of young ash trees, were brought in from a southern Minnesota nursery by Mr. Ruggles on July 20th. They began to go into the ground for pupation on July 22nd. Some were still to be found in the ash on July 23rd; a number had pupated by July 30th, forming pupal cells in the ground without spinning cocoons. Moths emerged on Aug. 28th to 31st. See p. 197 for technical descriptions of the larvæ and pupæ of these species.

From the above data it would seem that neglected spots in gardens or close to gardens must be carefully looked after. A neglected lot adjoining a flower garden, containing ragweed or burdock or giant bur-elder or hemp, appears to offer favorable breeding ground, from which a garden might be infested. Such weeds should be destroyed wherever found. The fall burning of dead weeds would not be efficacious unless made to include the stubs of the weeds close to the ground upon which the eggs are found.

THE IRRITATING HARVEST MITE OR "JIGGER."

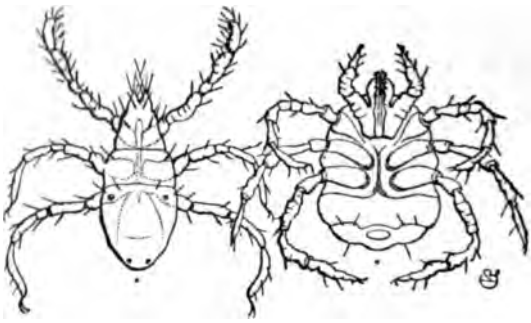


Fig. 80. The Irritating Harvest Mite ("Jigger") on right; the American Harvest Mite on left. Greatly enlarged. After Riley.

The right-hand figure in the accompanying illustration is a fair representation of a microscopic pest, a mite, not a true insect, which causes human beings more suffering in proportion to its size than any insect. Dr. Lugger, way back in 1896, speaks of them as "not common in Minnesota," but if his statement is correct, they certainly have been on the increase since then, for now a picnic party enjoying a summer day almost anywhere in our wooded areas is almost sure to be more or less afflicted, and to pay for its pleasure twenty-four or thirty hours later, a tax not anticipated. As a result of the attacks of this mite red blotches from the size of a nickel to that of a half dollar appear on the skin, accompanied by an intolerable itching. This inflammation may last for several days, driving the sufferer to distraction. After a while it gradually disappears. The unfortunate victim ascribes it frequently to "rash" or "hives" or "poison ivy," not realizing that it is the work of a tiny animal, barely visible to the naked eye, which lives normally upon low plants in shady places, and is rarely found in localities well exposed to the sunlight. But let a warm blooded animal frequent places where they are found, and, to use a slang expression, "there's something doing" for these tiny creatures quickly forsake their vegetable diet for one of blood. In the case of human beings the skin, easy of access, is attacked, and those with tender skin are the chief sufferers.

In the course of some investigations on this pest we found (Aug. 4, 1908) in wooded areas about Lake Minnetonka, large numbers of tiny mites on a species of goldenrod as well as other low plants, in no case more than fourteen inches above ground. On this occassion an assistant, Dr. Franklin, and myself, did all we could to be inoculated, walking amongst the shrubbery and weeds, reclining on them, rolling up sleeves, Dr. Franklin even taking off his shoes and stockings. Upon returning home, in order to test the efficacy of a preventive measure, one of us took a bath immediately, covering the body with a soapy lather, and putting on afterwards a *change of clothes throughout,* discarding for the time being everything worn in the woods. In this case the bathed one did not suffer, nor, strange to say, did the non-bathed, who served as a "check" on the experiment. However, as the "check," from experiments later, appears to be immune, and the writer is ordinarily a sufferer, it is fair to conclude that the above treatment is good. We believe that these pests were not as abundant at the date mentioned as they had been earlier in the season.

On August 5th, leaves known to be infested with a mite were placed next to the skin up the writer's sleeve and allowed to remain there several hours. This resulted in three or four infested spots on arm and shoulder, showing about twenty-four hours later.

On August 11th, we again tried to tempt this pest, and on August 12th, about thirty-two hours after exposure, a few red blotches appeared on the body of the writer. In the center of each a tiny red or orange spot could be observed with a magnifying glass, which we endeavored to dissect out for examination under the microscope, but without any definite result. The red globular body may be the body of the mite, or, as some claim, only a blister filled with the victim's blood. This remains to be seen. We applied Dioxygen, full strength, to two or three blotches a few times at intervals, and this appeared to allay the itching, though we hesitate to recommend it until a further trial.

"Jiggers" were noted as late as the last week in August, and it would seem that most of our woods are not desirable places to picnic from early summer until September, unless one takes certain precautions to prevent the disagreeable attacks of this creature.

We will call this little pest *Leptus irritans,* though it may be a stage of *Trombidium.* The Order of Mites contains such pests as itch-mites, scab mites, mange-producing mites, sheep-scab mites, as well as some forms which, at certain stages at least, are beneficial to man because of their preying upon grasshoppers or locusts and upon house flies. The writer has seen a bright red mite, *Trombidium scabrum* Say,

very common on plowed ground in the spring, destroying enormous numbers of the eggs of the cabbage maggot. Frequently four or five of these mites were observed about one cabbage plant, and very many eggs of the above pest were found with their contents sucked out by the mite.

It is a pity that a possible relative of the above useful animal should so far forget itself as to attack human beings. As a rule these attacks, beyond the extreme discomfort evident for several days are not dangerous, though it is claimed that erysipelas has followed severe attacks, as well as blood poisoning.

Captain Zimmerman, living on Enchantment Island, Lake Minnetonka, having found this pest troublesome on his own island, and upon the neighboring Phelps Island, has reduced their numbers materially by cutting out much underbrush, thus letting in the sunlight. He also by an ingenious contrivance, drew a cloth wet with tar and kerosene back and forth over the edge of the lawn next the shrubbery, as a result of which the pest practically disappeared from that locality. He states that he has also found that a mixture of lard and powdered sulphur rubbed on the skin allays the irritation. Sulphur in any combination appears to be an excellent agent.

Preventive measures: *A hot bath, lathering one's self with soap immediately after exposure, and putting on after the bath underwear and other clothes not worn at the time of infestation. A long interval (several hours) between exposure and bath, would render the bath inefficient. Flowers of sulphur dusted into stockings next the skin and under waist band is a good safeguard before entering suspected woods.*

Remedies: "*Moderately strong ammonia applied when symptoms are first manifest.* (Chittenden.)

"*A supersaturated solution of bicarbonate of soda or saleratus.* (Chittenden.)

These solutions should be used liberally and frequently.

Sulphur ointment applied to affected portions of the body.

Means leading to the lessening of this pest on private grounds and club grounds have been referred to above. Weeds, undesirable grass and useless shrubbery should be done away with as much as possible, allowing sunlight to replace the shade in such localities.

The name "Jigger" is evidently a corruption of "Chigger," which in turn comes from "Chigoe," a name applied to a flea in the tropics, which burrows in the skin of man.

TWO ENEMIES OF BEE KEEPERS.

THE BEE MOTH, OR WAX MOTH,

Galleria mellonella Linn.

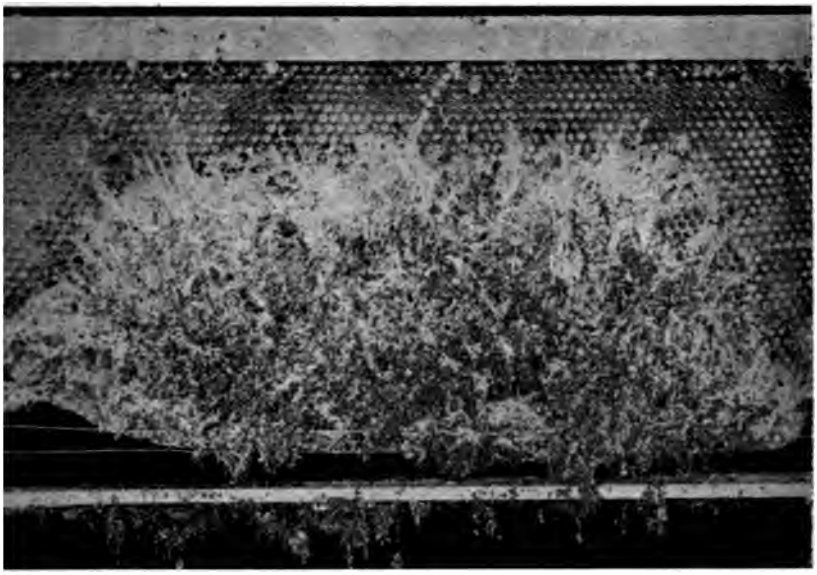


Fig. 81. Comb badly affected with work of Bee Moth. Original.

This insect, common as it is, does not appear to have received e attention it deserves, in the way of studying its life history, at e hands of Entomologists; at least, certain data in connection with s life cycle are apparently lacking, and experiments have been con-ıcted in the insectary with the object of shedding some light upon ese points.

Possibly the fact that modern hives, modern methods and conse-uently strong colonies have reduced this evil to a minimum with most e-raisers, accounts for the apparent lack of work in the past upon etails, for a vigorous colony of Italians, in a good hive can ordinar-y take care of this pest. But, let a dwindling colony (more par-ıcularly black bees) occupy a loose jointed hive, and the moth or r progeny obtains entrance. It is perhaps unnecessary to describe

the adult or the larva; the former, a brownish gray moth, is well shown in the illustration, as is the egg, larva at two stages, and the pupa in its cocoon.

The round pale white eggs, measuring about 4 millimeters in diameter, with reticulated surface, are laid singly or in masses during spring and summer, and evidently from choice or necessity in cracks and crevices, whence the young larvæ can reach the inside of the hives. In the insectary one large mass laid in a breeding cage under a flat piece of wax, contained 272 eggs, but as there were seven moths in the cage, more than one female may have been concerned in the laying. Three different sets of eggs, one set laid February 24th, one on

Fig. 82. Hive showing Bee Moth cocoons on side. Original.

February 26th, and one on February 28th, hatched in from 23 to 26 days, while two other sets, one laid April 1st, and another August 11th, hatched respectively in 19 days, and in from 14 to 18 days. In other words those laid on April 1st hatched April 20th, and of those laid on August 11th same hatched August 25th, and continued hatching until August 29th.

This shows a great variation in the duration of the egg stage, for the average of the first three lots was from 23 to 26 days, while the last two sets required much less time. It would seem then that one is justified in saying the eggs hatch in from 14 to 26 days. In nearly all insectary experiments the propensity to place the eggs in cracks and crevices was very noticeable.

Fig. 85. End of frame showing excavations in wood made by Bee Moth. Original.

The young larva, see Fig. 84, is pale flesh color, with light brown head. Mr. George Ainslie, employed in the insectary at the time of these experiments, describes this stage as follows:

"Length, 1 mm. Width, 2 mm. Body white. Head brownish with darker brown sutures between eyes and clypeus. Head oblong, twice as wide as long, clypeus slightly obtruded, V shaped from above, coming to an apex just at posterior margin of head. First thoracic segment largest of body, slightly wider than head, and nearly same shape. Anterior margin straight, and lateral ones convex. Legs same color as body. Second and third thoracic segments shorter than first and nearly as wide. About twice as wide as long. Abdominal segments 9. Lateral margins convex. There is a small bristle on the outer extremity of each side of each segment. Last two somewhat reduced in size. Posterior foot bifid. While larva very transparent. The alimentary canal is evident, usually being filled with brownish matter. Larva very active, moving alternately its thoracic legs and posterior leg, thus moving in a hitching, jerking fashion."

The adult larva is shown in Fig. 86. It is grayish in color, with a brown head, and its presence in a hive can be dected by the ragged and eaten appearance of the comb, and the silk which it spins wherever it goes, and by its excrement. They become full grown in about four weeks and are about one inch long. Before, or during the process of spinning their cocoons, they frequently hollow out the inner surface of the hive or frame by gnawing, directly under their cocoons, each hollow or depression fitting the lower surface of a cocoon; Fig. 83 shows the appearance of wood thus attacked. Within these cocoons they transform to pupæ. The pupa is *a rich brown* about 12 mm. long, the head is

rounded and blunt. From a point just above the height of the eyes a median dorsal ridge (carina) black in color, extends backward the whole length of the body, broken at each segment. A few scattered bristles are located on the last two segments.

Figs. 84, 85 and 86. Egg, much enlarged, young larva, and full grown larva of Bee Moth. Original.

The pupal stage, as observed in our insectary, is normally from 12 to 20 days, though the records show two exceptional cases where it lasted eight days and forty days respectively. This makes a period of a little over two months elapsing between the laying of the egg and the production of the moth, and there are doubtless at least two broods in Minnesota.

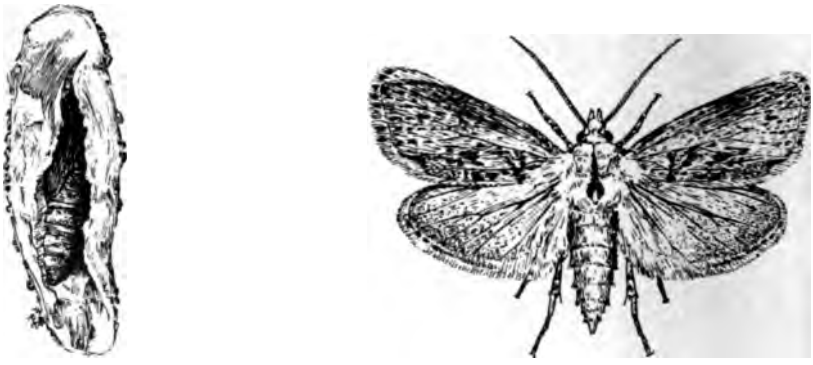


Fig. 87 and 88. Cocoon, pupa and imago of Bee Moth. Original.

As previously stated, Italian bees have but little to fear from this pest, the black bees being the particular sufferers, but stored comb honey, and stored comb in frames are in danger if not carefully watched. This is particularly true where such products are stored in places which are not accessible to cold. Normally eggs of the Bee Moth are laid only in the spring and summer, but let wax and honey already infested be placed in a fairly warm room, and breeding will continue indefinitely, as long as the food lasts. In this connection be it said, the larva can subsist a long time, evidently a month, in other words during its entire life, upon pure wax, as determined in insectary experiments here.

Remedies: *Keep Italian Bees in preference to Blacks, and use modern hives and modern methods. Bee Moth larvæ can be easily killed by confining infested comb in an air-tight receptacle and placing bisulphide of carbon therein. Two treatments at intervals of three weeks might be necessary.*

Carbon bisulphide is very volatile, and the gas, when mixed with air, highly explosive, therefore, bring no light near it. Our old comb, or comb-honey intended for feeding is kept in air-tight galvanized iron boxes, about two feet square at ends, and four feet long. The Bee Moth, in its various stages, is easily controlled under these conditions with bisulphide of carbon, as above suggested.

AMERICAN FOUL BROOD.

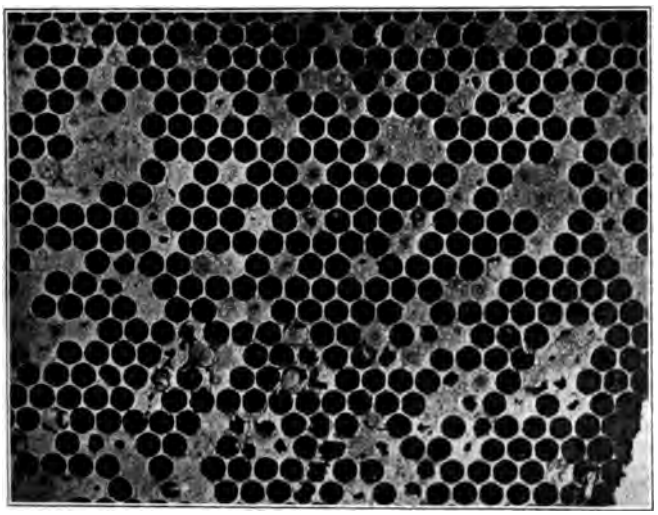


Fig. 89. Comb affected with Foul Brood. After Cowan.

This contagious bacterial disease, known as *Bacillus larvæ*, White, is undoubtedly the bee-keeper's worst enemy in the western states. This is in part because it is so little understood by the majority of bee-keepers, who do not realize how insidious a disease carried by spores or "germs" may be, and how easily it spreads from hive to hive.

Although called American Foul Brood, it is prevalent in Europe. It need not be confounded with the European Foul Brood or "Black Brood," which is not nearly so common as the first named disease, from which it can easily be distinguished as noted below. It calls for practically the same treatment as the first named.

placing, in a clean hive, infested frames, comb, or honey. The importance of this fact cannot be emphasized too prominently to the bee-keeper, and should be carefully borne in mind when handling bees.

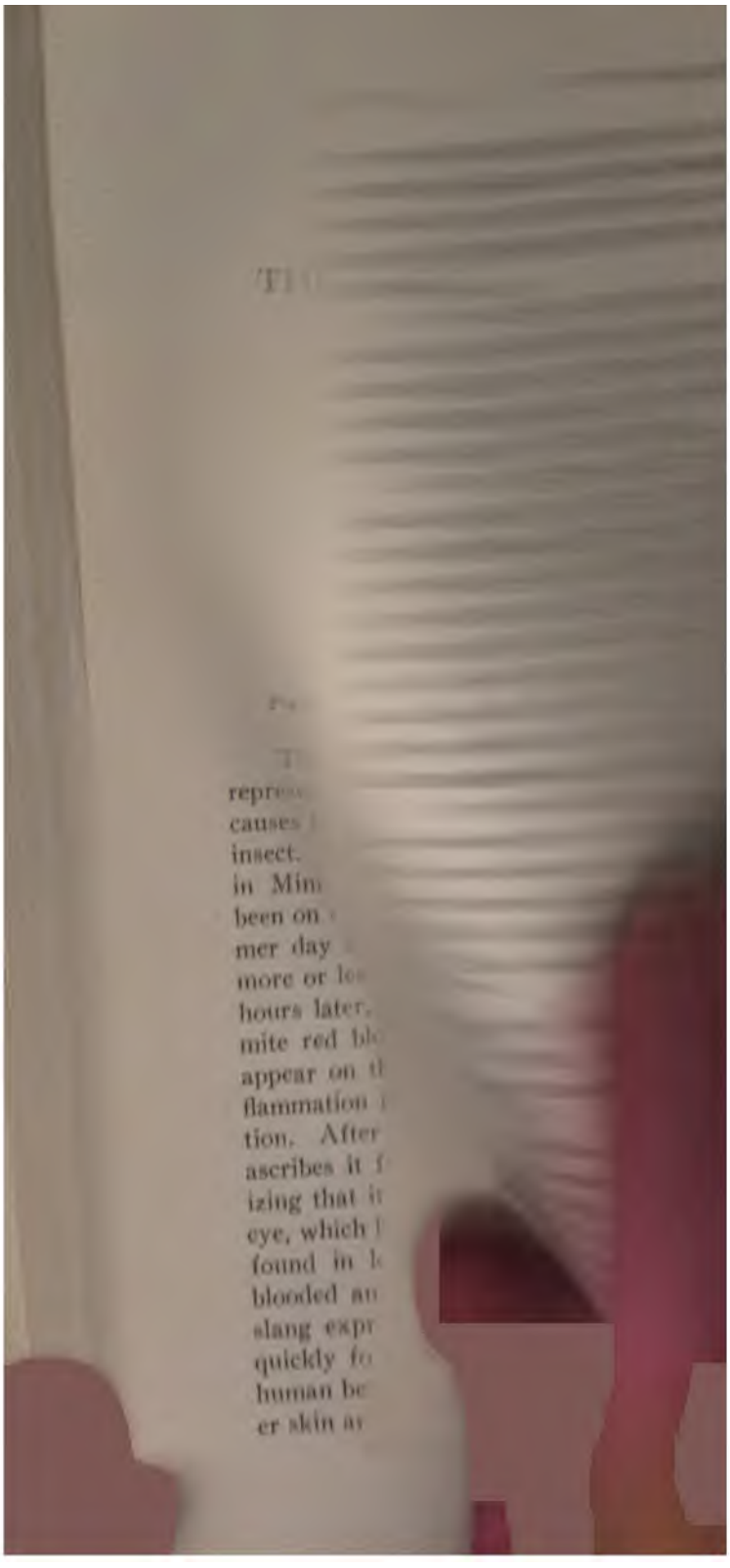
Remedies for American Foul Brood: Treatment is best done when honey is abundant, and *in the evening.* Remove diseased comb, and shake the bees into their own hive, having first placed in the hive clean frames with foundation starters. Let them build comb for four days. On the evening of the fourth day take out the combs which have been started, and which may be partly filled with diseased honey, shake the bees on to new frames with foundation starters, destroying the comb and honey which they first made before other bees have access to it. This should effect a cure. One's hands should be thoroughly washed, and the tools used in this work carefully cleaned with boiling hot water or alcohol to prevent contaminating another colony. The hive also should be disinfected previous to inserting the second set of frames with starters, preferably by placing straw in same and burning, slightly charring the interior. The alighting board and entrance should be disinfected in the same way. All infected honey and comb should be destroyed by burning, at night, to prevent robbing and consequent spread of disease.

The above is referred to as the McEvoy method, though substantially the same process was in use before it was employed by this gentleman.

A colony dwindling from the effect of Foul Brood, should be carefully safe-guarded against being robbed, since robbing may be the most prolific cause of spreading the disease.

If a bee-keeper bears in mind the infectious character of this disease, precautions to be observed in handling diseased colonies will naturally suggest themselves to him. Should he be in doubt as to whether Foul Brood is present, he should send for the State Bee Inspector, whose duty it is to inspect apiaries, notify the owners when Foul Brood is found, and show them how to handle it.

It may be said, in closing, that the disease known as "European Foul Brood" or "Black Brood" is on the increase, it it claimed, in this country and may be in time quite as common as American Foul Brood.



against the Cabbage Maggot we overflowed, as it were, into large truck gardens in this neighborhood where we could work upon a commercial scale.

The insectary, naturally closely allied to and belonging to the experimental garden, is at the north end of the plot, and consists of a work room, store room and dark room, comprising the woolen portion, which is 20x24 feet, and extending south from this a glass portion like a greenhouse 18x35 feet. The latter part is divided into a cool room where the temperature is practically the same as tha

[illegible] calling for that tempera[illegible] temperature of which i[illegible] the winter, thu[illegible] ather. Under th[illegible] for a bee cellar.

[illegible] it has proved it [illegible] four hundre[illegible] October 31s

four hundred and fourteen different experiments. These experiments have consisted mainly of work with lice affecting grain, their life histories, and what parasites affected them; with the Bee Moth, Clothes Moth, Stalk Borers, Oak Pruner, Maple Borer, Birch Borer, Apple Leaf Hopper, Clover Insects, Confused Flour Beetle, various plant lice, Cabbage Maggot, etc.

ABSTRACTS OF PUBLICATIONS REVIEWED IN EXPERIMENT STATION RECORD AND DEALING WITH INSECT PESTS OF FRUITS, BETWEEN JANUARY, 1908, AND OCTOBER, 1908.

For the benefit of our citizens who may wish to consult other than local publications treating of various insect pests which infest fruits, we have had compiled and insert here a list of publications, reviewed in the Experiment Station Record between January, 1908, and October, 1908. In the majority of cases the works referred to can be obtained by applying to the parties concerned in their publication. The list is nearly complete as given in the Record, and naturally it includes some things not grown in Minnesota. The numbers following each fruit as here given refer to the numbers of the titles of the articles and brief abstract in list following:

Apple: 1, 2, 3, 7, 8, 12, 13, 16, 17, 20, 23 27, 36, 37, 38, 42, 47, 50, 51, 52, 55, 56, 59, 62, 63, 74, 75, 79, 82, 92, 93, 94, 100, 103, 104, 105, 110, 111, 114, 119, 120, 123, 128, 132, 133, 134.
Blackberry: 12.
Cherry: 2, 10, 12, 20, 50, 53, 79, 100, 129.
Cranberry: 12, 30, 40, 111, 131.
Currant: 2, 4, 12, 16, 18, 48, 55, 58, 64.
Gooseberry: 12.
Grape: 12, 14, 19, 20, 27, 33, 34, 37, 43, 44, 71, 72, 74, 81, 88, 109, 112, 122, 129.
Insecticides: 111, 116, 117, 118, 119, 129.
Melon: 12, 80.
Plum: 2, 12, 20, 21, 47, 48, 53, 54, 59, 64, 74, 83, 95, 100, 104, 105, 114, 129.
Prune: 50, 54, 100.
Quince: 12.
Raspberry: 12, 18, 57.
Small Fruits: 129.
Spray Calendar: 15, 28, 101.
Spraying Suggestions, Receipts, Etc.: 102.
Strawberry: 5, 12, 18, 36, 61, 79, 136.
Tomato: 128.
Rose: 129.

General and Miscellaneous: 4, 6, 8, 9, 12, 17, 22, 27, 30, 36, 37, 38, 41, 47, 49, 51, 59, 60, 65, 66, 67, 68, 69, 73, 76, 81, 84, 87, 89, 90, 91, 96, 97, 98, 99.

1. Report of the Department of Entomology, E. D. Sanderson (N. H. Sta. Bul. 129, pp. 258 to 266, Durham, N. H.). A brief account of work on Gypsy, Brown tail and Codling Moth, and the Apple maggot.

2. Report of the Prof. of Entomology and Zoology, C. J. S. Bethune (Ann. Rep. Ont. Agr. Col. and Exp. Farm, 32 (1906) pp. 42-54 Guelph, Ont). Field experiments on oyster shell scale; lime-sulphur wash gave best results, with kerosene emulsion second. Crude petroleum found harmless and effective as winter spray on apple, pear, plum, cherry and black currant; dangerous, however, in summer.

3. Thirty-seventh annual report of the Entomological Society of Ontario, (Ann. Rep. Ent. Soc. Ont., 57 (1906) p. 120, pl. 7, fig. 36, Guelph, Ont.). Ravages and parasites of Codling Moth discussed, also the Oyster Shell and San Jose Scales.

4. Report on injurious insects and plant diseases for 1906, W. M. Schoyen (Beretning om Skadeinsekter of Plantesygdomme i Land-og Havebruget, 1906. Christiania: Grondahl & Sons, 1907, p. 30, fig. 14). Fruit flies, blister mite, currant saw fly and *Lecanium ribis* discussed.

5. The strawberry root louse: Life history and remedies, C. O. Houghton (Dela. Sta. Circ. 2, p. 4, Newark, Del.). Life history and remedies discussed.

6. New hemipterous fruit pests in Britain, F. V. Theobald (Jour. Econ. Biol., 2 (1907) No. 1, pp. 14-25, pl. 2). A considerable variety of leaf hoppers discussed, especially *Typhlocyba quercus, Chlorita flavescens,* and *C. vericula.* Parasites and remedies discussed.

7. Spraying for the Codling Moth, J. W. Lloyd (Ill. Sta. Bul. 114, pp 375-429, fig. 5, Urbana, Ill.). The first application for the Codling Moth should be timed preferably with reference to the most advanced young apples rather than the average development of the entire setting. Other matters connected with this subject discussed somewhat fully.

8. Two common scale insects, C. O. Houghton (Del. Sta. Circ. 3, p. 6, fig. 1, Newark, Del.). Life histories, habits and food plants of, and remedies for the Oyster shell and Scurfy scales discussed.

9. The San Jose and other injurious scale insects of Tennessee with methods for their control, G. M. Bently (Tenn. Sta. Bul. Vol. XIX, No. 2, pp. 11-34, fig. 23, Knoxville, Tenn.). A general popular account of the San Jose Scale, with a discussion of remedies, also notes on other common scales.

12. Control of insect pests and diseases of Maryland crops, J. B. S. Norton and T. B. Symons (Maryland Sta. Bul. 115, pp. 145-210, fig. 38, College Park, Md.). Different crops discussed with their injurious insects and remedies for them.

13. Spraying the apple orchard, E. D. Sanderson, Y. J. Headlee and C. Brooks (N. H. Sta. Bul. 131, pp. 11-56, fig. 36, Durham, N. H.-. Status of apple industry, Codling Moth and spraying experiments in New Hampshire during 1906 discussed.

ng, L. R. Taft (Mich. Sta. Spec. Bul. 37, p. 32, fig. 10, Agri-
ge). Methods of control of San Jose Scale, black rot and mil-
, etc.

ing calendar, L. R. Taft and C. D. Smith (Mich. Sta. Spec.
Agricultural College).

h annual report of the State Entomologist of Montana, R. A.
Sta. Bul. 64, pp. 33-45. Bozeman, Mont.). Notes of various
ing the Codling Moth and Currant Span Worm.

Monthly Bulletin of the division of Zoology, H. A. Surface
Agr., Monthly Bul. Div. Zool. 4 (1907) Nos. 11, pp. 385-414;
, pl. 6. Harrisburg, Pa.). Remedies for San Jose Scale, Tent
ıd Codling Moth discussed.

ome injurious insects in 1906, R. S. Macdougal (Trans. High-
Soc. Scot., 5 ser. 19 (1907) pp. 173-188). Remedies discussed
ısects, as follows: *Lampronia rubiella* on raspberries, rasp-
ground beetles attacking strawberries and currant gall mite.

ating grape-vine flea beetle, Foures-Diacon (Prog. Agr. et
ıt) 28 (1907) No. 20, pp. 582-585). Discussion of a certain pro-
ide formula for treating the insect.

ts affecting fruit trees, C. J. S. Bethune (Ont. Dept. Agr. Bul.
4, Guelph, Ont.). A popular account of the insect pests of
r, plum, cherry, peach and grape, and formulas given for va-
ıes.

rus xylographus as an orchard pest, O. E. Bremner (Cana-
1907) No. 6, pp. 195-196, Guelph, Ont.). Commonly reported
ınly dead or dying trees, this insect is noted as attacking
and plum trees.

sene remedy and the fruit fly, G. Compere (Jour. Dept. Agr.
5 (1907) No. 4, pp. 244-245, pl. 1). A self-feeding kerosene
in catching the fruit fly. Kerosene odor attractive to it.

ating Codling Moth with arsenicals, J. Barsacq (Jardin, 21
4, pp. 124, fig. 2). A discussion of the use of Paris green and
d for this insect.

Terrapin Scale, J. G. Sauders (U. S. Dept. Agr., Bur. Ent.,
fig. 3). *Eulecanium nigrafasciatum*, a peach pest described,
lants, natural enemies and remedies discussed.

ing, A. Dickens and R. E. Eastman (Kans. Sta. Bul. 145, pp.
Manhattan, Kans.). A general discussion of this subject as
ıards and vineyards.

calendar (N. Y. Cornell Sta. Bul. 243, pp. 127-136, Ithaca,
ısual arrangement for this sort of thing.

rt of the Entomologists, C. H. and H. T. Fernald (Mass. Sta.
199-205, Amherst, Mass.). Includes notes on cranberry insects
treatment for white flies in greenhouses, and scale insects.

ites of the grape vine, E. Durand (Flore et Faunedes Para-
. Montpellier: Coulet & Sons, 1907, p. 89, fig. 55). Analyti-
dentification of the common insect and fungus pests of grape
edies discussed.

34. The biology and means of combating phylloxera, Moritz (Mitt. K. Biol. Aust. Land n Forsten, 2 (1907) No. 4, pp. 64-66). Remedies discussed.

36. Early spring applications of insecticides for the oyster-shell scale. The occurrence and distribution of San Jose Scale in Vermont, W. Stuart (Vt. Sta. Rpt. 1906, pp. 293-297, pl. 1, Burlington, Vt.). Treatment discussed.

37. Twenty-second report of the State Entomologist on injurious and other insects of the State of New York, 1906, E. P. Felt (N. Y. State Mus. Bull. 110, pp. 39-186, pl. 3, fig. 2, Albany, N. Y.). Includes a discussion of insect pests of fruit and shade trees, including San Jose and scurfy scales and the grape vine root worm.

38. Second Annual Report of the State Entomologist, E. F. Hitchings (Ann. Rep. State Ent. Maine, 2 (1906), p. 77, pl. 2, fig. 21, Orono, Me.). Includes practical notes on the apple tree tent caterpillar, strawberry weevil, oyster-shell bark louse, wooly aphis, etc.

40. Some insects injurious to truck crops. The cranberry span worm. The striped garden caterpillar. F. H. Chittenden (U. S. Dept. Agr. Bur. Ent. Bul. 66, pt. 3, pp. 21-32, fig. 2). *Cleora pampinaria* discussed; its habitat, life history, etc., given.

42. The mealy aphis on apple trees, G. d'Utra (Rev. Agr.) (Sac Paulo) 12 (1907) No. 143, pp. 243-249). Life history and remedies discussed.

43. Thread worms in grape vines and pear trees, G. Korff (Prakt. Bl. Pflausenbau n Schutz 5 (1907) No. 6, pp. 67-69, fig. 1). Worms of the genus Mermis found in these plants, and attention called to the fact that they are commonly parasites of insects.

44. The sphinx of grape vines, R. Brunet (Rev. Viti. 28 (1907) No. 707, pp. 5-7, pl. 1). Habits, biology and natural enemies and remedies for *Sphinx elpenor* discussed.

47. Report of the Entomologist, C. O. Houghton (Dela. Sta. Rpts. 1904-1906, pp. 77-107, Newark, Del.). Remedies discussed for the apple leaf miner and the plum curculio; also contains among other things, notes on the oyster-shell scale.

48. Injurious insects and other animals observed in Ireland during the year 1906, G. H. Carpenter (Econ. Proc. Ray. Dublin Soc. 1 (1907) No. 11. XIX, pp. 421-452, pl. 6, fig. 11). Includes notes on plum aphis, oyster-shell scale, black currant mite.

50. Papers on deciduous fruit insects and insecticides. The pear thrips, D. Moulton (U. S. Dept. Agr., Bur. Ent. Bul. 68, pt. 1, p. 16, pl. 2, fig. 8). An account of *Euthrips pyri* on peach, apricot, pear, prune, cherry, apple and other trees, with life history and technical description of the insect; parasites and treatment also discussed.

51. Papers on deciduous fruit insects and insecticides. The spring canker worm, A. L. Quaintance (U. S. Dept. Agric., Bur. Ent., Bul. 68, pt. 2, pp. 17-22, pl. 2). Remedies for the spring canker worm discussed.

52. Papers on deciduous fruit insects and insecticides. The trumpet leaf miner of the apple, A. L. Quaintance (U. S. Dept. Agric., Bur. Ent., Bul. 68, pt. 3, pp. 23-30, pl. 1, fig. 1). The life history, history, distribution

and food plants (apple, crab, raspberry) of *Tischeria malifoliella* given. Remedies discussed.

54. The Howard scale, E. P. Taylor (Colo. Sta. Bul. 120, p. 19, fig. 4, Fort Collins, Colo.). Food plants (Pear, plum, prune and others) given and remedies discussed.

55. Codling moth, C. Borner (Min. Bl. K. Preuss. Verwalt. Landeo Domanen U. Forsten, 3 (1907) No. 4, Aus. Beilage pp. 104-107, fig. 6). Appearance, life history and remedies.

56. Proceedings of the 19th annual meeting of the Assoc. of Econ. Ent. (U. S. Dept. Agr., Bur. Ent., 67, p. 145, pl. 1, fig. 7). Among other papers the following may be noted:

(a) That by H. E. Hodgkiss on aphid eggs on apples (pp. 2-30).
(b) That on the pear blister mite on apple leaves by P. J. Parrott (pp. 43-46).
(c) Those on the codling moth by A. F. Burgess and E. D. Ball (pp. 53-55 and pp. 55-75).
(d) That by B. H. Walden on new saw-fly injurious to peach leaves, (pp. 85-86).
(e) That by E. P. Taylor on the Howard scale (pp. 87-93).
(f) That by W. E. Collinge (pp. 119-123) on the eradication of the black currant-gall mite.

57. Notes on insect, fungus and other pests, R. S. Macdougall (Jour. Bd. Agr. (London) 14 (1907) No. 5, pp. 290-300). Includes an account of *Cetonia aurata* and *Harpalus ruficornis* as injurious to strawberries.

58. Report of the Zoologist, 1906, C. Warberton (Jour. Roy Agr. Soc. England, 67 (1906) pp. 267-281, fig. 16). Remedies given for *Incurvaria capitella* on currants, and for the pear midge.

59. Evidence of the entomologist and botanist before the select standing committee on agriculture and colonization, 1906-7, J. Fletcher (Ottawa Govt. 1907, pp. 113-140). Prevalence of and remedies for the following insects discussed: San Jose scale, apple maggot, plum curculio, etc.

60. Entomological notes, C. W. Howard and G. Peringuey (Rhodesian Agr. Jour. 4 (1907) No. 5, pp. 471-482). The habits and means of controlling fruit flies are briefly outlined.

61. On the life history, habits, and economic relations of the white grubs and May beetles, S. A. Forbes (Illinois Sta. Bul. 116, pp. 447-480, Urbana, Ill.). Includes a note of May beetles.

62. Codling moth investigations during 1903 and 1904, F. Garcia (New Mexico Sta. Bul. 65, p. 29, dgm. 3, Agricultural College, N. M.). An account of the different broods.

63. The Codling moth in eastern Washington, A. L. Melander and E. L. Jenne (Wash. Sta. Bul. 81, p. 24, fig. 7, Pullman, Wash.). Treatment discussed.

64. The more important Alerodidæ infesting economic plants, with description of a new species infesting the orange, A. L. Quaintance (U. S. Dept. Agr., Bur. Ent., Bul. 12, Tech. Ser. pt. 5, pp, 89-94, pl. 1, fig. 2), Mention made of species on orange, cocoanut, custard apple, strawberry, Rubus, currant, peach, plum, fig., etc.

65. The scale insects of fruit trees, J. P. Bounhiel (Ecale, Agr. Alger. Maison-Carree, Inform. Agr. Bul. 3, p. 16, pl. 2). Life histories of various species given and preparation of sprays discussed.

66. The San Jose Scale and remedies, F. Sherman, Jr. (Bul. N. C. Dept. Agr., 28 (1907) No. 5, p. 62, fig. 15, West Raleigh, N. C.). Life history, history in North Carolina, and a list of food plants given. Treatment discussed.

67. The San Jose scale in North Carolina, F. Sherman, Jr. (Nul. N. C. Dept. Agr. 28 (1907) No. 6, p. 18, fig. 2, West Raleigh, N. C.). A detailed statement of the distribution of this insect in North Carolina.

68. The fruit maggot fly pests, G. Quinn (Jour. Dept. Agr. So. Aust, 10, (1907) No. 11, pp. 701-710, fig. 14). The habits of various species discussed; treatment discussed.

69. The fruit fly, C. P. Lounsbury (Agr. Jour. Cape of Good Hope, 31 (1907) No. 2, pp. 186-187). Treatment discussed.

71. Experiments in the treatment of grape vines for phylloxera, P. C. Westre (Rev. Agr. Vit. et Hort. 1907, Nos. 77, pp. 169-172; 78, pp. 178-182; 80, pp. 213-219; 81, pp., 230-235, fig. 6). Symptoms of infestation and damage caused by the pest. Treatment given.

72. Two unusual grape pests, V. Mayet (Prog. Agr. et Vit (Ed. 1 'Est) 28 (1907) No. 40, pp. 400-403, pl. 1). *Psyche graminella* and *Agelastica alni* reported attacking grapes. Habits and life histories given.

74. Report of the Entomologist, J. B. Smith (N. J. Sta. Rep. 1906, pp. 515-609, pl. 15, fig. 18, New Brunswick, N. J.). Observations and discussions on the San Jose, Oyster-shell and scurfy scales and the peach soft scale, plum curculio, apple borer, pear-leaf blister mite, pear psylla, rose chafer, grape galls, plant lice, etc. Remedies considered to a considerable extent.

75. The Codling Moth, R. S. Woglum (N. C. Dept. Agr. Ent. Circ. 20. p. 16, fig. 7, West Raleigh, N. C.). Treatment discussed.

76. Fruit fly (Jour. Dept. Agr. So. Aust., 10 (1907) No. 12, pp. 869-870). A copy of the regulation enforced by South Australia against the importation of trees, plants and fruits from countries infested with the fruit fly.

79. Insect notes for 1907, Edith M. Patch Maine Sta. Bul. 148, pp. 261-282, pl. 3, Orono, Maine). Includes biological and economic notes on the forest tent caterpillar, apple-tree tent caterpillar, cherry tree tortrix, strawberry weevil, rose chafer and various other insects.

80. The melon louse, A. F. Conradi (Gulf Coast Mag. 3 (1907) No. 1, pp. 47-53, fig. 6, Clemson College, S. C.). Damage described, treatment given, and parasites considered.

81. Some items of information for orchardists and fruit growers relative to certain dangerously injurious insects and diseases, G. G. Atwood (N. Y. Dept. Agr., Bur. Hort. Insp. Bul. 1, p. 20, pl. 48, Ithaca, N. Y.). For the guidance of fruit growers directions are given for the preparation of certain insecticides and fungicides for San Jose scale, the grape root worm and many fungi.

82. The apple maggot or railroad worm, C. E. Hood (Mass. Sta. Circ. 3, p. 3, fig. 2, Amherst, Mass.). Life history outlined and remedies suggested.

83. The lecanium or soft scales, C. E. Hood (Mass. Sta., Circ. 6, p. 3, fig. 2, Amherst, Mass.). Brief biological and economic notes on apricot scale, New York plum scale, terrapin scale, etc.

84. The San Jose Scale, H. A. Surface (Zool. Bul. Penn. Dept. Agr., 6 (1907) No. 6, pp. 171-200, pl. 4, Harrisburg, Pa.). A brief general account of the insect, including a list of the food plants.

88. Insects injurious to the vine in California, H. J. Quayle (Cal. Sta. Bul. 192, pp. 99-140, fig. 24, Berkeley, Calif.). A general account, with a discussion of the remedies for the more important ones.

89. Directions for treatment of insect pests and plant diseases, E. D. Sanderson (N. H. Rep. Bd. Agr. 29, (1905-6) pp. 151-175, Durham, N. H.). Treatment of orchard fruits, shade trees, gardens, greenhouse crops, etc., for the control of insect pests and fungous diseases discussed.

90. Report of Nursery Inspector, E. D. Sanderson (Rpt. Bd. Agr. N. H., 29 (1907) pp. 287, 294, Durham, N. H.). Three nurseries inspected. A report on conditions found, and as to the status of the gypsy and brown-tail moths.

91. Nursery and orchard inspection, Economic Entomology, H. A. Surface (Zool. Bul. Penn. Dept. Agr., 6 (1907) No. 4, pp. 97-128, pl. 2, Harrisburg, Pa.). A general account of various subjects.

92. The excessive abundance of apple moths, G. Korff (Prakt. Bl. Pflanzenbau u Schutz n. ser., 5 (1907) No. 10, pp. 112-116). *Simaethis pariana.* a note on its great abundance during the year, with suggestions for treatment.

93. Papers on deciduous fruit insects and insecticides. The lesser apple worm, A. L. Quaintance (U. S. Dept. Agr. Bur. Ent., Bul. 68, pt. 6. pp. 49-60, pl. 1, fig. 1). *Enarmonia prunivora,* an account of the injury caused by it; history, distribution, life habits and remedies discussed.

94. The apple-tree tent caterpillar, A. L. Quaintance (U. S. Dept. Agr. Bur. Ent., Circ. 98. p. 8, fig. 4). A general discussion. Treatment given.

96. The San Jose Scale, A. F. Conradi (S. C. Sta. Bul. 134, p. 20, fig. 12. Clemson College, S. C.) A general account, including a list of food plants.

97. Spraying for San Jose Scale, T. B. Symons and G. F. Weldon, (Md. Sta. Bul. 123, pp. 139-152, fig. 2, College Park, Md.). A general account with results of experiments.

98. The use of soluble oils against San Jose Scale, W. W. Chase (Ga. Bd. Ent., Circ. 6, p. 11, fig. 4, Atlanta, Ga.). Results of insecticide experiments.

99. The lime-sulphur wash, A. L. Melander (Washington Sta. Pop. Bul. , p. 4, Pullman, Wash.). General directions.

100. Experiments with Paris green, A. Tullgren and C. G. Dahl (Medel K. Landtbe. Styr. (Sweden), 1907, No. 6. 125, p. 45). The results of various experiments on stone fruits and different varieties of apples.

101. Spray calendar, W. E. Britton and G. P. Clinton (Conn. Sta. Bul. 59, folio, New Haven, Conn.). The usual thing in this line.

102. Suggestions to those contemplating spraying. F. L. Washburn (Minn. Sta. Press Bul. 31, p. 11. St. Anthony Park, Minn.). Recipes and directions.

103. Notes on insect, fungus, and other pests, R. S. Macdougal (Jour. Bd. Agr., London, 14, 1907, No. 8, pp. 477-484, fig. 1). Recommendations for treatment of apple saw fly, corn saw fly and other pests.

104. Control of scale in old apple orchards, P. G. Parrott, H. E. Hodgkiss, and W. J. Schoene (N. Y. State Station Bul. 296, p. 30, pl. 4). Treatment of San Jose Scale on peach, plum, pear and apple trees discussed.

105. Saving old orchards from scale, F. H. Hall (N. Y. State Sta. Bul. 296, popular ed., p. 10, fig. 1). A popular edition of the above.

106. White fly in California: C. W. Woodworth (Cal. Sta. Circs. 30, p. 16, fig. 12). Attention called to its appearance in California and to the necessity of vigorous work against it. Its life history and habits described.

107. White fly eradication, C. W. Woodworth (Calif. Circ. 32, p. 15, fig. 11, map 1). Organization recommended for work against the insect on account of work already done.

109. The grape vine root borer, F. E. Brooks (W. Va. Sta. Bul. 110, pp. 19-30, pl. 5). Life history and injury described and treatment discussed.

110. Seventh Report of the State Entomologist, W. E. Britton (Conn. State Sta. Rep. 1907-8, pt. 5, pp. 266-338 11, pl. 16, fig. 6). The use of various gases for fumigating nursery stock and scions of apple and peach for scale insects discussed.

111. Report of the Entomologist, J. B. Smith (N. J. Sta. Rep. 1907, pp. 387-478, pl. 3, fig. 1). Codling moth, black peach aphis, San Jose scale, elm, leaf beetle, bagworm, cranberry pests and other insects discussed. Treatment discussed. Preparation of various insecticides given.

112. *Chelonia capa*, R. Brunet (Rev. Vit., 29 (1908) No. 733, p. 5, pl. 1). Caterpillars injurious to buds of grapes. Hand picking of caterpillars recommended.

114. Orchard spraying, O. M. Morris and J. F. Nicholson (Okla. Sta. Bul. 76, p. 32, fig. 22). An account of spraying for codling moth, plum curculio, canker worm and other pests, and for various fungus diseases of the apple.

116. Homemade miscible oils, C. L. Penny (Del. Sta., Bul. 79, pp. 1-34, fig. 2). An account of experiments in making these insecticides for use against scale insects, also an account of the chemical problems involved in combining these insecticides with certain fungicides.

117. Miscible oils: How to make them, C. L. Penny (Penn. Sta. Bul. 80, p. 20, fig. 1). Special formulas recommended for winter and summer use against scale insects.

118. Orchard tests of miscible oils, C. O. Houghton (Del. Sta. Bul. 79, pp. 35-40). An account of experiments with these oils.

119. Entomological notes, C. J. S. Bethune (Ann. Rept. Ontario Agricultural College and Expt. Farm, 33 (1907), pp. 53-55, 56-60). Oyster-shell and San Jose Scale and scurfy scales, plant lice, white grubs and other insects discussed; also the making of the lime-sulphur mixture.

120. Report of the State Entomologist for the year 1906, S. Lampa (Meddel K. Landtbr. Styr. (Sweden), 1907, No. 121 (2), p. 32, fig. 2). Codling Moth, tussock moth and other insects discussed.

122. Papers on deciduous fruit insects and insecticides. Grape root worm investigations in 1907, F. Johnson (N. S. Dept. Agr. Bur. Ent. Bul. 68, pt. 6, pp. 61-68, pl. 2). An account of observations and experiments and recommendations given.

123. Papers on deciduous fruit insects and insecticides. Demonstration spraying for the Codling Moth (U. S. Dept. Agr., Bur. Ent. Bul. 68, pt. 7, pp. 69-76). An account of the results of extensive demonstration spraying experiments against this insect.

124. The pear midge, P. Marchal (Ann. Soc. Ent. France, 76 (1907), No. 1, p. 5, fig. 14). Injurious near Paris. Life history and injury described. Remedies given.

128. Some observations concerning the effects of freezing on insect larvæ. J. S. Hine (Ohio. Nat., 8, (1908) No. 4, pp. 258-260). An account of experiments. The tomato hawk moth and the fall canker worm considered.

129. Insect Pests, J. Craig, M. V. Slingerland and C. R. Crosby (N. Y., Cornell Sta. Bul. 252, pp. 335-349, fig. 12). Underlying principles and economic aspects of spraying discussed. Directions given for preparing insecticides and for applying them in the control of the chief insect enemies of apples, plums, cherries, quinces, peaches, pears, nursery stock, grapes, small fruits, roses and garden and greenhouse plants.

131. Report on the study of insects injurious to cranberries during the summer of 1907, C. B. Hardenburg and O. G. Malde (Wis. Sta. Rpt. 1907, pp. 309-320, fig. 2). Biological notes given and remedies discussed.

132. Report on the work of the section for plant protection, 1906-7, C. Brick (Stat. Pflanzenschutz Hamburg, Bot. Staatinst. (Ber) Abt. Pflanzenschutz, 9 (1906-7), pp. 1-18). A detailed report is given of the extent of importation of apples. Notes on insect pests, particularly the San Jose Scale, and plant diseases found on this fruit also given. A report also given upon the condition of live plants imported from various countries.

133. Does it pay to spray Nebraska apple orchards? R. A. Emerson and F. E. Denny (Neb. Sta. Bul. 106, pp. 3-20). Results of practical experiments under average conditions given.

134. The apple maggot or railroad worm. A. L. Quaintance (U. S. Dept. Agr., Bur. Ent. Circ. 101, p. 12, fig. 2). Remedies given. Food plants and life history discussed.

135. The insect pests of peach trees. F. Lafont (Prog. Agr. et Vit., 4 (1907) No. 49, pp. 680-685). Biological and economic notes on various species injurious to peaches.

136. State nursery inspection, J. G. Moore (Wisconsin Sta. Rpt. 1907, p. 369-378, fig. 3). San Jose scale and other pests in nurseries noted among others, the strawberry root louse.

A COMPARATIVE STUDY OF THE EXTERNAL ANATOMY OF PLANT LICE.

BY R. A. VICKERY, M. A.

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The following article by Mr. Vickery represents a thesis prepared for the degree of M. A. at the University of Minnesota. The work was begun, and with the exception of a few additions, and some revision, made in our laboratories, practically completed under the direction of Prof. O. W. Oestlund, to whom the author is particularly indebted for guidance and encouragement.

The object of the investigations reported upon was to name and classify some of the external characters of the Aphididæ in such a way that systematic work in this group could be made easier and more accurate.

To present the subject in complete form the author has been obliged in a few instances to incorporate in the body of the text some well known facts and already recognized terms, but this in no way detracts from the originality of the work as a whole, and I believe he has added materially to our working knowledge of plant lice.—F. L. W.

In many of the published descriptions of plant lice it is impossible to make more than a guess as to what species the author is describing. Generic and even family characters have been used in specific descriptions. In the work upon which this paper is based about one hundred species represented by large numbers of individuals in different stages, were studied with 2-3 and 1-6 objectives. Particular attention was given to the antennæ, wings, cornicles and cauda, as these organs afford some of the best characters, and the rostrum, hind legs, anal plate and genital plate also afford good characters. These points have been illustrated by plain line text figures, as such figures are easier to use, and show the points just as well as the more elaborate plates.

The presence or absence of certain organs, such as the lateral tubercles, or certain sensoria of the antennæ cannot be used in specific descriptions; but the arrangement or character of these organs may be so used. Describers of species pay too little attention to minute characters. Published figures accompanying descriptions should contain detailed drawings of the important organs. This method would advance our knowledge of the value and constancy of certain characters, and make it possible finally to make up practical keys to the genera and species of the Aphididæ. It is hoped that this paper will help in some degree toward that end.

The Head in General: The head of aphids is small, either ansverse or quadrate in outline and is closely articulated with the othorax. The anterior margin between the bases of the antennæ lled the frontal margin is of value in distinguishing genera and other oups. Three different types of head may be recognized in the *phididæ*. First, there is the primitive transverse form found in *chnus* and allied genera; where the frontal margin is straight and ere are no frontal tubercles. Then there is the quadrate form of the gher genera where the frontal margin is concave. This is due to the gles of the head on which the antennæ are situated being drawn t into frontal tubercles. These tubercles are of value in distinguishg the higher genera of the *Aphididæ,* but do not have as great xonomic value as is usually attached to them, as they grade cometely into those species of *Aphis* characterized by the absence of ontal tubercles. Sometimes the inner margins of the frontal tubereş are provided with a protuberance or swelling; they are then said be gibbous. If this protuberance is conical or spine-like they are othed. The third or convex type is found in the gall-makers. Here ıe frontal margin is convex and the anterior angles of the head instead f being drawn out are rounded off. As a result the antennæ and nterior ocellus are situated a little more toward the ventral side than ı the other forms. In *Lachnus* and *P. vagabundus* the head is divided y a middorsal suture.

The Eyes: In the larva there is a group of three ocelli with lliptic lenses on each side of the head, which undoubtedly represent ıe larval eyes of other insects. They appear very early in the embryo nd may be seen as bright red spots through the abdominal wall of ıe viviparous female. The larval eyes of *Aphids* are remarkable in ıat they persist in the adult as ocular tubercles alongside the compound es. The compound eyes begin to develop in the embryo just in front f the larval eyes, but cannot be seen externally at that time. They e precocious in their development and are present in the larva. They pear externally and are probably functional after the first moult. he lenses are hemispherical and are few in number, about forty at is time. In the adult they range in number from seventy-five to two ındred and fifty. The dorsal ocelli are three in number, one located the inner margin of each compound eye, and one located on the ons, either on the frontal margin or ventral to it. They are not esent in the apterous forms. The compound eyes and the dorsal elli, which are primarily correlated with the development of wings, e not present, or are rudimentary in some of the subterranean forms, here they have been lost from lack of use.

The Antennae: The antennae have from three to six cylindrical joints. The two short sub-equal basal joints form the scape, the others form the flagellum. In the early larval stage the flagellum is two jointed; during the larval development the proximal one of these lengthens, and one or two additional joints are cut off from its distal end. In some genera the first antennal joint is gibbous or notched on its inner side; this is especially noticeable in *Myzus* and *Phorodon*.

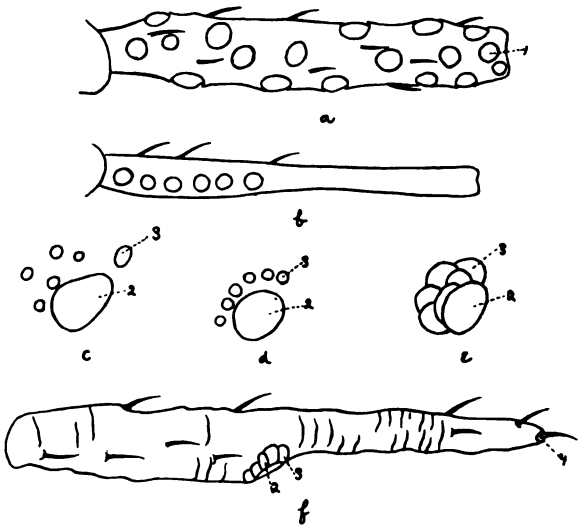

Fig. 94. a. 3rd antennal joint of *A. opulus*. b. Same of *Cal. marginella*. c. Scattered marginal sensoria. d. Marginal sensoria in a row. e. Marginal sensoria in a pyramidal group. f. Sixth antennal joint of *Mel. salicis*: 1, Circular sensoria. 2. Terminal sensoria. 3. Marginal sensoria. 4, Terminal sense hair of the spur.

The third joint is usually the longest. Some times (*P. populicaulis* and *populi-transversus*) it has a short tooth-like process on its outer side near its base. The sixth joint is always modified by the development of a spur, which arises as a finger-like outgrowth at its distal end. In some of the higher genera the spur is as long as, or longer than the third joint, and has been considered a separate joint by some authors. In *Pemphigus* and related genera it is shorter than the basal part of the sixth joint.

The structures found on the antenna are hairs and sensoria. The hairs may be classified as unmodified hairs and modified hairs. The unmodified hairs found in *Lachnus* and *Chaitophorus* are long and slender and do not differ from the ordinary body hairs. The modified hairs are of three varieties: Short spine-like hairs found generally in the genus *Aphis;* longer hairs with spatulate tips, found typically in

Macrosiphum; and the short spine-like terminal hairs of the spur, found in all *Aphids.* In *Pemphigus vagabundus* these terminal hairs are scattered on the spur, and have an oval sensorial surface at their base.

The sensoria are organs of special sense, which may be divided into three classes according to form and position. First, the *terminal* sensoria, present in all *Aphididæ*, located laterally and singly at the distal ends of the penultimate and ante-penultimate joints. Where there are only three joints the third is the only one with a terminal sensorium. These sensoria are large, circular and fringed with a row of fine hairs. Inside the row of hairs there is a groove which marks off the raised membrane. In some species of *Phylloxera* the terminal sensorium of the third joint is long and oval and extends nearly the whole length of the joint. Second, the circular sensoria which belong typically to the third joint. These are circular, usually smaller than the terminal sensoria, sometimes but not always fringed with hairs. In the *Pemphiginæ* and *Schizoneurinæ* the circular sensoria are modified respectively into transverse and annular sensoria. The transverse sensoria are long, oval in outline, and run traversely across the joint. The annular sensoria form a narrow ring around the joint. Third, the marginal sensoria, which are small sensoria grouped around the terminal sensorium of the last joint. The most primitive arrangement is in *Lachnus,* where they are scattered or in scattered groups near the terminal sensorium. In other genera they are arranged in a single row beside the terminal sensorium, or grouped in a peculiar pyramidal arrangement beside it. A peculiar condition is found in *Drepanosiphum* and *Mastopoda,* where two of the marginal sensoria are enlarged and located one at each end of the terminal sensorium; while a row of four smaller ones occupies the usual position beside it. The marginal sensoria are fringed in this case. At the end of the second antennal joint there is a minute sensorium which resembles these marginal sensoria closely.

Besides these types there are also fused sensoria, which are of two kinds; those formed by the fusion of sensoria of the same type, and those formed by the fusion of sensoria of different types. The first formed by the fusion of either circular, transverse, or annular sensoria. The second by the fusion of one or two transverse or annular sensoria with a terminal sensorium.

The joints of the antenna are usually imbricated. Sometimes these imbrications appear under high power as rows of short sharp points forming regular patterns. Then again the points seem to have united to form sharp ridges facing the distal end of the joint. In the

spur these ridges become very prominent and run nearly around or around the joint.

The Rostrum: The clypeus, labrum, mandibular laminae, and first maxillary laminæ form a raised tubercle on the ventral side of the head, which may be appropriately called the trophic tubercle. The clypeus is in one piece, nearly oval in outline as you look down upon it from the ventral side. The labrum joins the distal end of the clypeus. It is composed of a rectangular basal part which suddenly narrows at its distal end into a long pointed triangular distal part covering a groove in the labium. The mandibular lamina lies partly under the clypeus and the labrum; the exposed portion having the shape of a segment of a circle. The first maxillary lamina lies under the mandibular lamina, and the labrum, usually only a small portion of it is exposed, but this varies in the different species. The labium is lengthened into a long rostrum. This is seen in its most primitive or generalized condition in Lachnus, where (*L. laricis*) it is five-jointed. The first two joints are grooved on their anterior faces; the third perforated; the fourth and fifth are grooved. The suture between the second and third joints is diagonal. There has been some question as to whether the rostrum is three or four jointed. This difference of opinion has arisen because of the obscurity of the suture between the first and second joint. By careful examination this suture can be observed and the four joints made out. But in the most primitive genus, *Lachnus,* the fourth or terminal joint is in some species divided by a very distinct suture and a fifth joint is present. This is probably the primitive condition. The rostrum varies greatly in length in the different genera. In some it reaches hardly beyond the first coxæ while in others, as some *Lachninæ*, it is much longer than the body. There is some difference in the relative lengths of the joints which might be used as a specific character. In *Lachnus* and *Melanoxanthus* the trophic tubercle is very hairy. In the other genera there are typically two pairs of hairs on the clypeus, a row of three hairs on each

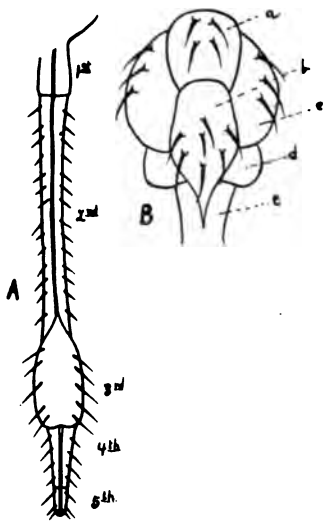

Fig. 2.

Fig. 95. The mouth parts of Aphididae: A, Rostrum of Lachnus laricis. B, Trophic tubercle of Macrosiphum: a, Clypeus; b, labrum; c, mandibular lamina; d, maxillary lamina; e, first joint of the labrum or rostrum.

nandibular lamina, about five hairs on the labrum, and none on the irst maxillary laminæ.

The Prothorax: The prothorax is usually short and of small ize, sometimes bent under the mesothorax so that it cannot be seen rom the dorsal side. But in other genera it is as long as it is broad nd nearly as large as the mesothorax. The undivided pronotum sually bears a lateral tubercle on each lateral edge. Sometimes here is only a single short spine-like tubercle, in other genera there re several of these tubercles in a group. The episterum is a small nterior rectangular thickened piece. The area of the epimerum is ot thickened; it bears a spiracle and sometimes a tubercle. The legs rticulate with these two pieces and with the sternum which is small.

The Mesothorax: The mesothorax is a large segment in all lant lice. The tergum is plainly divided into præscutum, scutum, cutellum, and post-scutellum. The præscutum is usually an equi-ateral triangular piece with its base pointed forward. But in some orms (*Phylloxera*) it is rectangular and broader than it is long. The arge scutum is divided into two semi-circular halves by the apex f the præscutum and a mid-dorsal suture. The prominent scutel-um is about half as wide as the thorax and is sometimes divided long the mid-dorsal line by a suture. The post-scutellum slants ackward and downward under the metatergum, so that very little f it is exposed. It is broadly triangular with an obtuse apex point-ng posteriorly. The sternum called *thoracic plate* is divided by longi-udinal and transverse sutures into four parts. The anterior parts rticulate with the episternum. In *Callipterus* the posterior prices re much smaller than the anterior pieces. In *Tetraneura* the pos-erior pieces are almost square. It is difficult to make out the epi-ternum and epimerum of the mesothorax, but there is a T-shaped ature on the side of the mesothorax which probably separates these vo regions. The anterior one is the region of the episternum, the osterior one, the region of the epimerum.

The Metathorax: The metathorax is reduced and closely ised with the mesothorax. The tergum is usually divided by a trans-erse suture into an anterior and posterior parts. The region of the isternum and epimerum cannot be made out distinctly. The sternum not thickened, except in some cases on its anterior border.

The Wings: There is need of homologizing the wing veins of phids with the wing veins of other insects. The names given here, ised on Comstock's system, were decided upon from a study of other duced wings, such as those of Psocus, and from a study of the ab-ormal venations found so frequently in plant lice.

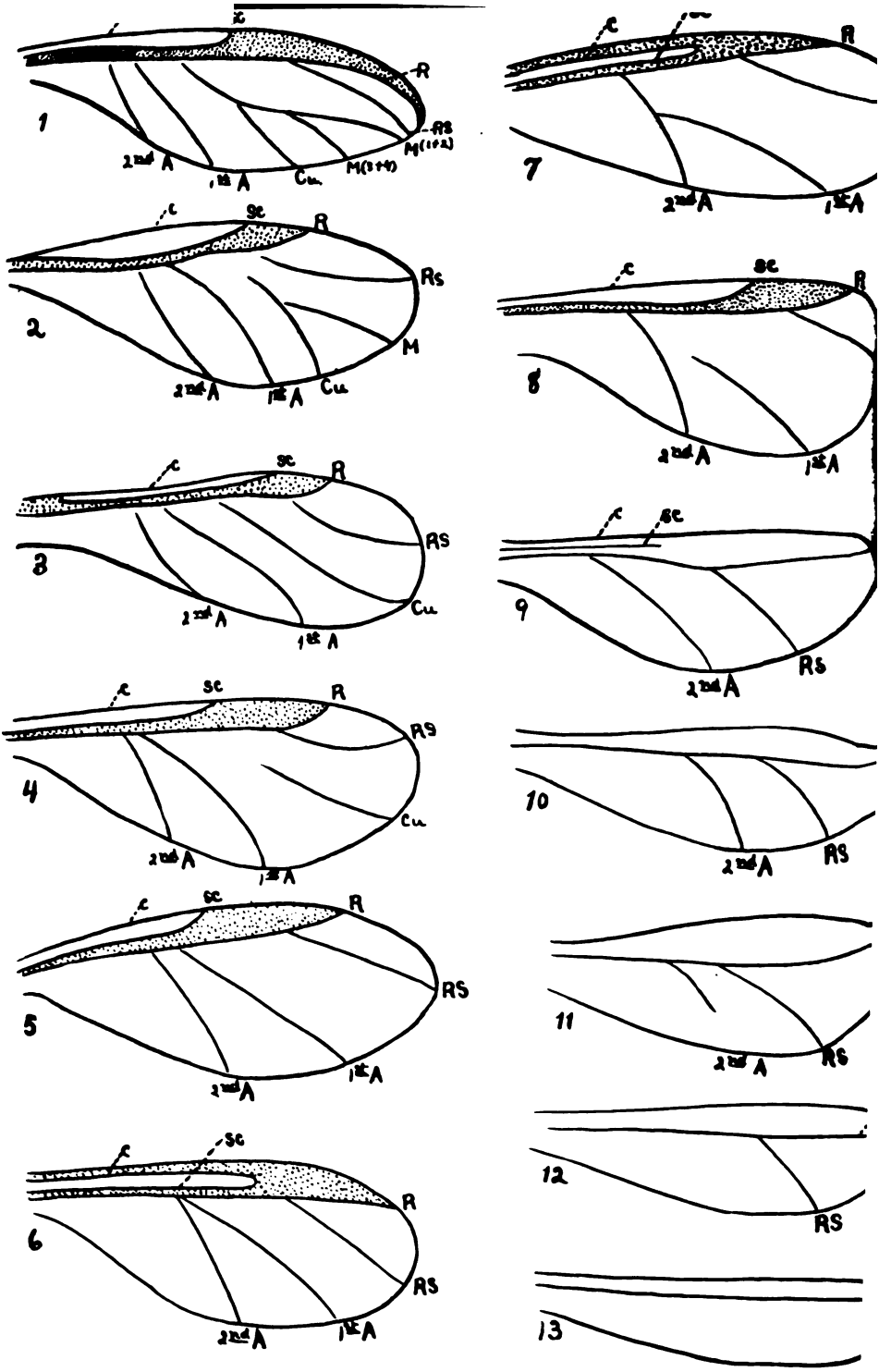

Fig. 3

Fig. 3. The wings of Aphididae: 1. Front wing of Lachnus longistigma. 2. Schizoneura lanigera. 3. Pemphigus vagabundus. 4. Colopha ulmicola. 5. Chermes pinifolii. 6. Phylloxera punctata. 7. Phylloxera quercus. 8. Phylloxera depressa. 9 Hind wing of Melanoxanthus salicti. 10. Chaitophorus populicola. 11. Hamamel

As the wings of the Aphididæ are specialied by reduction, it seems probable that these abnormalities are generally reversions, as they usually take the form of added veins or branches. There is nearly always a distinct vein on the costal margin of the front wing, and sometimes also of the hind wing, which, without question, represents the costa. The strong vein, posterior to this, is formed by the fusion of the proximal parts of the veins of both the costo-radial and the cubito-anal system. The thickened anterior margin of this vein running from the base of the wing to the proximal end of the stigma is the subcosta. The posterior margin of this vein, which is not thickened except where it forms the posterior border of the stigma, is the radius, while the stigmatic vein is the radical sector. The three-branched vein, usually called the third discoidal, seems to me to represent the united cubitus and media. The first two branches counting from the costal margin of the wing represent the media, and the third branch represents the cubitus. The next two veins usually called the second and first discoidals are the first and second anals, respectively. The third anal is not present.

As the wings of Aphididæ become reduced the media disappears and only the cubitus remains in *Pemphigus*. In *Chermes*, the cubitus has disappeared, and in *Phylloxera depressa*, which represents the limit of reduction in the front wing, the first anal has also disappeared.

The most primitive hind wing, which is nearly the same as the front wing of *Phylloxera depressa*, is found in *Melanoxanthus* and *Lachnus*, where the costa and subcosta are both present. In this wing I think that the vein usually called the second discoidal represents the radial sector, or that it corresponds to the stimatic vein of the front wing instead of to the second discoidal. The other discoidal is the second anal. The veins of the hind wing have probably been lost in the following order: Subcosta, costa, second anal, radial sector. So that the most reduced hind wing has only the unbranched radius.

The Legs: The legs of the *Aphididæ* do not differ greatly from the legs of other Homoptera. In the gall-makers and in the fundatrix of some other genera the legs are very short. In the higher genera the legs are long and slender. The extreme length of the hind legs in these genera is correlated with their habit of kicking them up when alarmed, that is, they are specialized as organs of defense. The coxa in *Aphids* is small and has no trochantine. The short trochanter is fused with the femur. The suture between the trochanter and femur is straight, but is oblique in *Chermes*. In the lower genera the femur is about as long as the tibia. In the higher it is only half as long.

In *Drepanosiphum* and *Aphis frondosa* there is a tubercle on the posterior side of the distal end of the femur. The hairs on the femur, except in *Lachnus* and *Melanoxanthus,* are arranged in irregular longitudinal rows. The long slender tibia is very hairy in some genera. In *Monellia* it has several spines at its distal end. A two-jointed tarsus with an oblique suture between the joints is typical of *Aphids.* The proximal joint which is about half as long as the distal one, is generally set into the end of the tibia. In *Chermes* it is provided with a pair of sucking disks. The distal joint has two long curved claws, but lacks a pulvillus. In *Phylloxera, Chermes* and *Hormaphis* there is a pair of tenent hairs on the dorsal side of this joint not far from its distal end. In *Mastopoda* the tarsus is represented by a single short thumb-like joint.

Minute circular (sensoria) similar to the ones found on the second joint of the antenna, and on the wings, are found on the legs. There are usually four on the trochanter, two dorsal and two ventral. There may be from one to sixteen near the proximal end of the femur. There are many different arrangements of these, so that it might be possible to use them as specific characters in some genera.

In the oviparous female of *Nectarosiphum rubicola, Rhopalosiphum hippophæ, Callipterus trifolii, Toxoptera graminum, Macrosiphum pisi,* and others the tibia of the hind leg is swollen for its whole length, and is thickly dotted with clear pits which closely resemble the sensoria of the antennæ. The tibia in this case has some function in connection with oviposition. I have not been able to examine the sexual forms of enough species to determine how far this condition is characteristic of the oviparous female.

The Abdomen: There are nine abdominal segments in *Aphididæ.* It is difficult to make out the exact number of segments on account of the usual swollen condition of the abdomen. The first seven segments are provided with spiracles, the first two of which are close together. The fifth segment bears the cornicles. The eighth bears the genital plate, while the ninth bears the anal plate and the cauda.

Any one of the first eight segments may bear tubercles or glands. Some genera, such as *Drepanosiphum* and *Callipterus* have a pair of prominent conical tubercles on the dorsal side of each of the first two or three abdominal segments. Each of these is tipped with a single short stiff hair. On the dorsal part of the eighth segment in *Siphocoryne archangellicæ* there is a single tubercle tipped with two hairs.

The lateral tubercles are found on the first eight segments in most of the higher genera. They are of different shapes and may be of value for specific characters. In the simplest form there is only a single small rounded tubercle, but sometimes, as in *Chaitophorus spinosa,* there are two, three, or four of these tubercles close together. In some species certain of the tubercles are of considerable length. In *Aphis symphoricarpi* the tubercles are not present, but there is a large circular transparent area which probably represents them.

The glands are found in the gall-formers principally. They may be on the dorsal side of every segment of the body except the ninth abdominal, or only on a few segments. There may be as many as six longitudinal rows or only two, so that they are of value in classification probably for specific characters.

The hairs are of several kinds. There are the slender curved body hairs, which may be either fine or coarse; the thick, spine-like hairs of *Chaitophorus spinosa;* and glandular hairs with knobbed tips. These last show several variations. In the larva of *Siphocoryne xanthii* they are short with large swollen ends and raised bases. In *Chaitophorus* and *Callipterus* they are long and only slightly swollen at the tip. In *Macrosiphum* they are of medium length and have spatulate tips. The dimorphous forms of *Chaitophorus* are armed with peculiar modified hairs (flabellæ) which have been described by Bucton and other authors. These hairs are flattened out into fan-like organs which show several longitudinal rib-like markings.

The cuticle of the abdomen is usually ornamented with rows of minute points similar to the imbrications of the antennæ. Sometimes there is also a network of hexagonal markings, which are probably a specialized condition of the ordinary ornamentation.

The Cornicles: The cornicles are situated on the fifth abdominal segment. *Lachnus* exhibits the most primitive cornicle, which has been called the tuberculate type. The body wall in this case is raised into a large round hairy tubercle. The opening is raised slightly above this tubercle so that this cornicle is composed of two parts, the broad, hairy proximal part, and the narrow, hairless distal part. This has not been distinguished before from the short broad cornicle found in *Callipterus* and *Chaitophorus,* which may be called the *truncate* cornicle. This type does not have the hairy basal part. A third type of cornicle is the cylindrical, which is long, slender and uniform in diameter. The truncate and cylindrical cornicles were probably developed directly from the tuberculate type. The incrassate or fourth type of cornicle is only a modification of the cylindrical form. This

type has three varieties; if it is enlarged at the base it is not distinguished by any particular name, if it is enlarged in the middle it is called vasiform, if it is enlarged at the end it is called clavate. In the gall-makers the cornicles, when present, are reduced to mere pores level with the surface of the body. This is probably a specialized and not a primitive condition. In *P. populi-transversus* the cornicle is present in the larva but not in the adult.

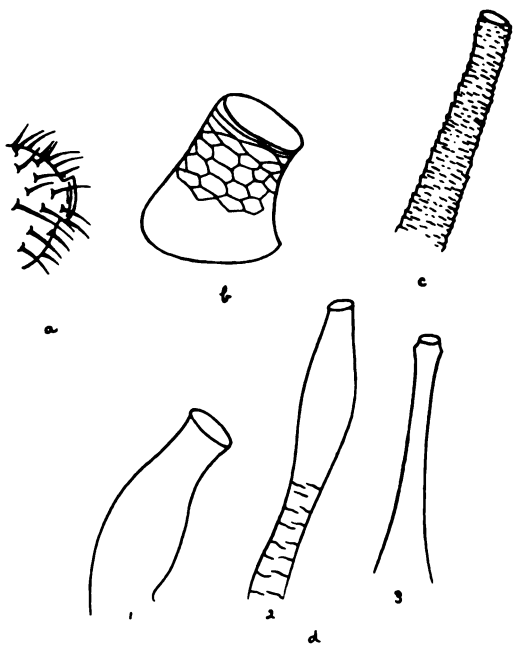

Fig. 97. Illustrating types of cornicles. a. Tuberculate type of Lachnus longistigma. b. Truncate type of Chaitophorus salix. c. Cylindrical type of Aphis. d. Incrassate type of the higher genera. 1, vasiform; 2, clavate; 3, cornicle incrassate at base.

When looking down upon the cornicle the large circular opening shows plainly. This opening is closed by a semi-circular valve, which can be pulled inward by a long slender valvular muscle attached to its inner side, and inserted on the posterior edge of the sixth abdominal sternite. There is a muscle attached to the base of the cornicle and inserted on the pleurite of the fifth abdominal segment, which elevates the cornicle. The ornamentation of the cornicle in the higher genera is interesting, and may be used to a certain extent as a specific character. Some show only the ordinary imbrications of the cuticle of the rest of the body. While others show only fine imbrications near the

se, which become more marked distally, and grade into a hexagonal ;ure near the end. In some of the higher genera there is a deep rrow encircling the cornicle near its distal end.

The Cauda: The cauda is an extension or appendage of the ;t abdominal segment. In *Lachnus,* which shows more primitive aracters than any other genus of the *Aphididæ,* the ninth segment is unded at the end and there is no distinct cauda present. In those nera where a distinct cauda is present four predominant types may be :ognized The conical form found in *Aphis* and in the larva and pupa the higher forms is about two or three times as long as it is broad d is directed slightly upward. The ensiform type of the higher nera, which was probably derived from the conical form, is very long d slender, curved upward, and sometimes enlarged in the middle. ıe globular form which may also have been derived from the conical pe, has its end swollen on the ventral side into a large globular ap-ndage. The obsolete cauda found in the gall-makers is the result of generation probably from a conical type. The cauda is in this case very short rounded extension of the ninth segment.

The hairs on the cauda very often have a definite arrangement ıd afford good specific characters. In the ensiform cauda there is a rminal curved hair and a row of stout hairs on each side. Each ıir corresponds to one on the opposite side, so that there may be om two to fourteen pairs. On the dorsal side of the globular type ere is often a prominent spine which is not armed with hairs. The ıticle of the under side of the cauda is covered with a thick mass of ort sharp points. The dorsal side is imbricated. In *Aphis* there is transparent surface on the dorsal side of the cauda near its base. his may be a provision for a movement of the cauda.

The Anal Plate: The anal plate is situated on the ninth ab-ıminal segment just ventral to the cauda. In its typical form it is arly hemispherical, but in the larva and pupa it is not much more an a flattened plate on the ventral side of the abdomen anterior to e anus. In *Callipterus* and related genera the anal plate is emarginate ıen seen from the dorsal side. There are some species where it is ly divided by a shallow notch, while in others this notch is deepened that the anal plate is divided into two parts, one on each side, with : cauda, which is not much longer than they are, attached almost be-:en them. The anal plate is always thickly covered with hairs. On ventral border there is a row of three protuberances called genital nature by Buckton, each of which bear several short slender hairs,

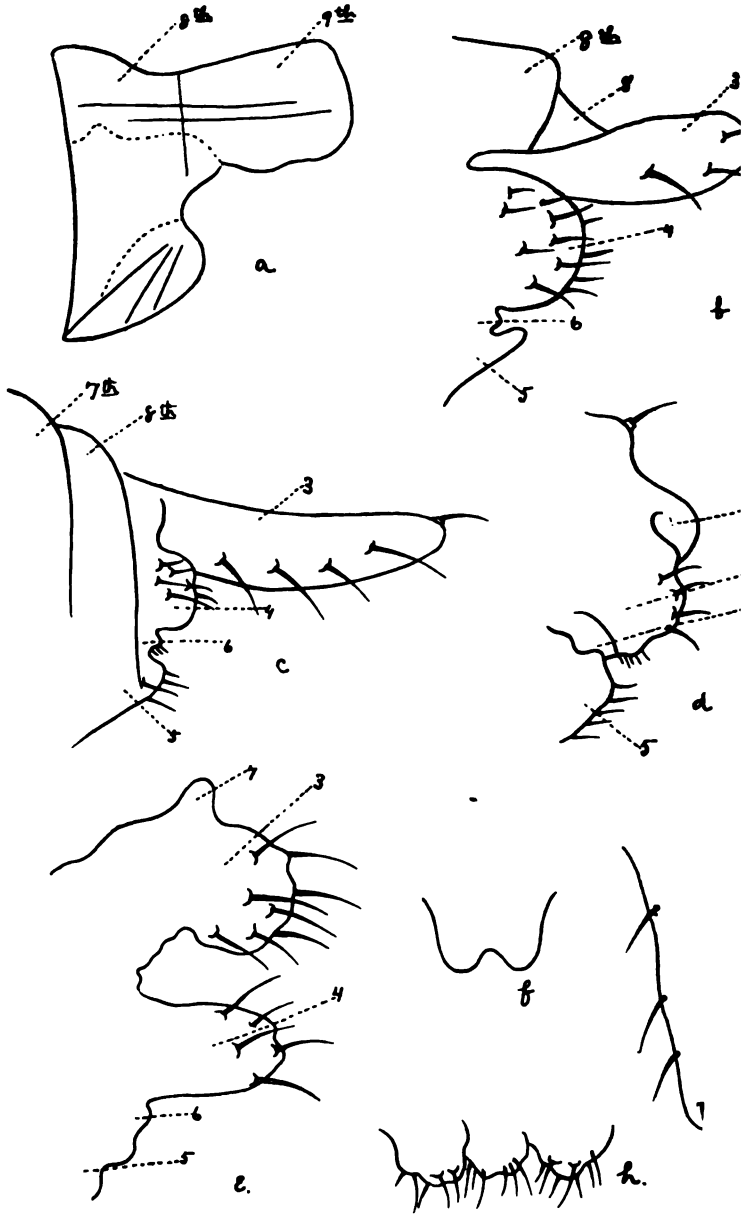

Fig. 5.

Fig. 98. Organs of the eighth and ninth segments. a, Phylloxera depr has an elongated 9th segment but lacks a cauda. b, Conical cauda of A. Ensiform cauda of Macrosiphum. d, Obsolete cauda of P. populicaulis. cauda of Cal. bellus. f, Bifid anal plate of Cal. ulmifolii. g, Ensiform from the dorsal side, showing the arrangements of the hairs. h, Genit of Macrosiopum. 1, anal opening; 2, genital opening; 3, cauda; 4, a genital plate; 6, genital armature; 7, tubercle on the cauda; 8, unpigme *the base of the cauda.*

pointing downwards over the genital opening. This armature helps to hold the young after they are born until they get their legs free.

The Genital Plate: The genital plate belongs to the eighth abdominal segment, and is situated just ventral to the genital opening. It is semi-circular in shape when seen from the ventral side, with the circumference pointing posteriorly projecting somewhat beyond the genital opening. There is usually a row of hairs in a semi-circle around the rim, and sometimes others not in rows anterior to these.

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THREE NEW HYMENOPTEROUS PARASITES OF THE CABBAGE MAGGOT.

In the course of some insectary work on the Cabbage Maggot during the summer of 1907, three new parasites were reared from its puparia by R. L. Webster, at that time in charge of our breeding experiments. These were named by Charles T. Brues, of the Public Museum, Milwaukee, Wis. His description of the species follows:

Figs. 99, 100, and 101 are from drawings of type specimens made in the entomological laboratory.

FAMILY DIAPRIIDÆ.

Loxotropa pegomyiæ, sp. nov.

FEMALE. Length 2 mm. Black, shining; legs including coxæ, brownish-yellow. Antennæ rufo-piceous, with black club. Head very highly polished; quadrate when seen from above and slightly narrowed behind, the occiput margined. Front with a deep transverse impression at the base of the antennæ, and a distinct submarginate frontal ledge upon which the anntennæ are inserted. Eyes rounded, rather small, clothed with a few scattered erect hairs. Face below the antennæ trapezoidal, higher than wide, its surface very coarsely and irregularly wrinkled; the lateral margins distinctly raised to form a broad rounded rim or margin. Mouth opening large, acutely margined on the sides; mandibles retracted; palpi dull yellow. Antennæ 12-jointed, the scape nearly straight, rather slender, one-half as long as the flagellum; pedicel obconical, nearly twice as long and much thicker than the first flagellar joint which is about one-half longer than thick; following funicular joints nearly quadrate, the apical ones becoming moniliform and a trifle wider. Club very large, three-jointed, nearly as long as the scape, the first two joints each about as wide as long, the apical one conically pointed and one-half longer. Thorax shining; pro- and metapleuræ wooly. Mesonotum without parapsidal furrows, but with more or less distinct broad parapsidal depressions. Scutellum shining, with a single basal fovea; its posterior quadrate portion with distinct grooved lines laterally. Metathorax irregularly rugose; deeply emarginate behind; with a median carina which meets a strong transverse one that follows the posterior margin; also with a lateral carina which fades out anteriorly. Abdomen elongate, highly polished; toward the tip obsoletely shagreened and furnished with a few bristly hairs. Petiole less than two times as long as wide, deeply and closely punctate; second segment more than twice as long as the following together, gradually

widened toward the apex; following growing sharply narrower to the pointed tip. Legs yellow, the femora, especially the anterior pair darker below. Wings hyaline, the submarginal vein reaching about two-fifths the length of the wing; basal vein very distinct.

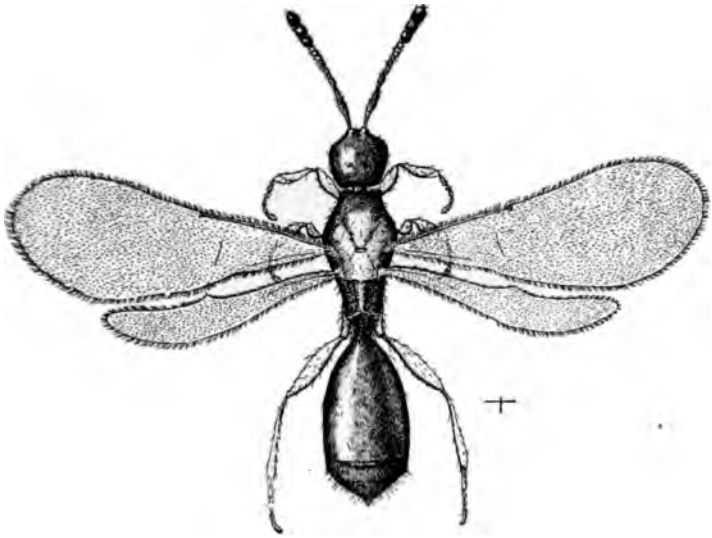

Fig. 99. *Loxotropa pegomyiæ* Brues. Female.

MALE. Differs by its uniformly paler legs and filiform black antennæ with brownish-yellow scape. The pedicel is distinctly shorter and thicker than the first flagellar joint; first and second about equal, each two and one-half times as long as thick; following joint about twice as long as thick, subequal; the last longer.

Described from three specimens bred from *Pegomyia brassicæ* Bouche, This resembles the western *L. californica* Ashmead, but differs by its much darker and more slender antennæ. The scutellar fovea is quadrate and the lateral grooves entire.

FAMILY ALYSIIDÆ.

Mesocrina pegomyiæ, sp. nov.

FEMALE. Length 2.75 mm. Shining black legs and abdomen beneath brownish-yellow. Head shining, three times as wide as thick. Antennæ 28-jointed, one-half longer than the body; filiform, slender. Pedicel and second flagellar joint about equal, the first one-third longer; following joints growing gradually shorter; scape brownish-yellow, the remaining joints black. Face shining, smooth; convex, about two times as wide as high; clypeus honey-yellow, convex, with a groove at the base; strongly protuberant. Maxillary palpi six-jointed, pale, their tips attaining the tegulæ; labials rather short. Mandibles honey-yellow, tridentate; the anterior tooth very blunt, median one the longest, posterior one small. Mesonotum with obsolete furrows anteriorly and a small circular fovea just

before the scutellum. Scutellum elongate, with a broad and deep transverse fovea anteriorly, which is imperfectly divided by a median carina; sides anteriorly strongly carinate; posterior portion strongly convex, highly polished. Metanotum rugose anteriorly, with a transverse carina and constriction, behind which are two large completely closed areas separated by a median carina; apically with an elongate petiolar area and a quadrate lateral area on each side. Pleuræ shining. Mesopleura depressed at its junction with the metapleuræ, the latter above with a deep circular fovea and below with a coarse punctate frenum. Abdomen subpetiolate, scarcely longer than the thorax. Petiole twice as wide as long as the tip; basally with a median triangular impression on each side of which is a smaller rounded one; surface irregularly aciculate; spiracles placed slightly before

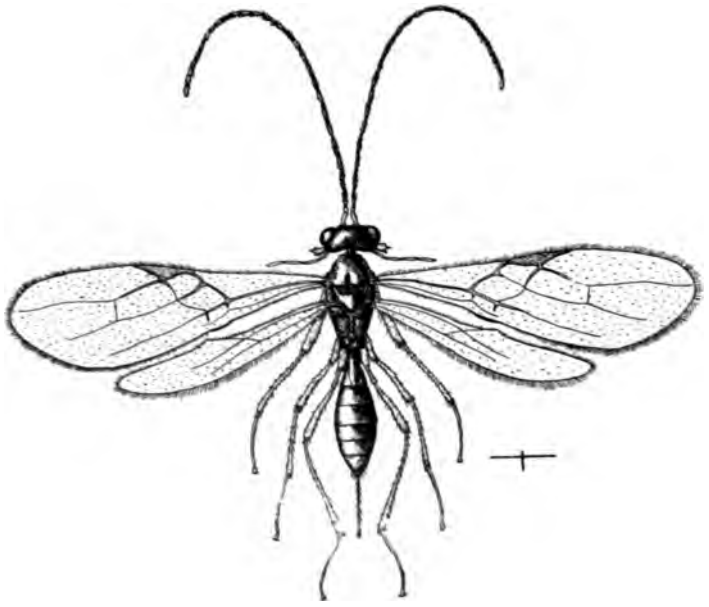

Fig. 100. *Mesocrina pegomyiæ* Brues. Female.

the middle, connected with the posterior angles by a lateral raised line. Second segment smooth, as long as the first; gradually widened to its apex, where it is as wide as long; following segments about equal in length, the third the widest. Ovipositor nearly as long as the abdomen. Legs slender, dull yellow. Wings, hyaline, the veins grayish; stigma narrow, but distinctly triangular, being about four times as long as thick. Three cubital cells; first section of the radius extremely short, second over twice as long as the second transverse cubitus; recurrent nervure interstitial; submedian vein distinctly longer than the median.

Described from one specimen bred from a puparium of ***Pegomyia brassicæ***, Bouche.

This seems to be the only North American species remaining in the genus as at present understood.

Aphœreta pegomyiœ, sp. nov.

FEMALE. Length 2.2 mm. Ovipositor 1 mm. Black, the first two antennal joints, first abdominal segment and the legs bright honey-yellow. Head twice as wide as thick, the occiput distinctly emarginate; front and vertex smooth, without grooves except for the trace of a longitudinal one at the ocelli, which however does not extend toward the occiput. Eyes rounded with a few sparse hairs. Mandibles yellow, tridentate, all the teeth acute. Antennæ 21-jointed, distinctly longer than the body; second flagellar joint almost twice as long as the first; following joints elongate, but growing shorter, covered with a pale pubescence. Palpi long, pale.

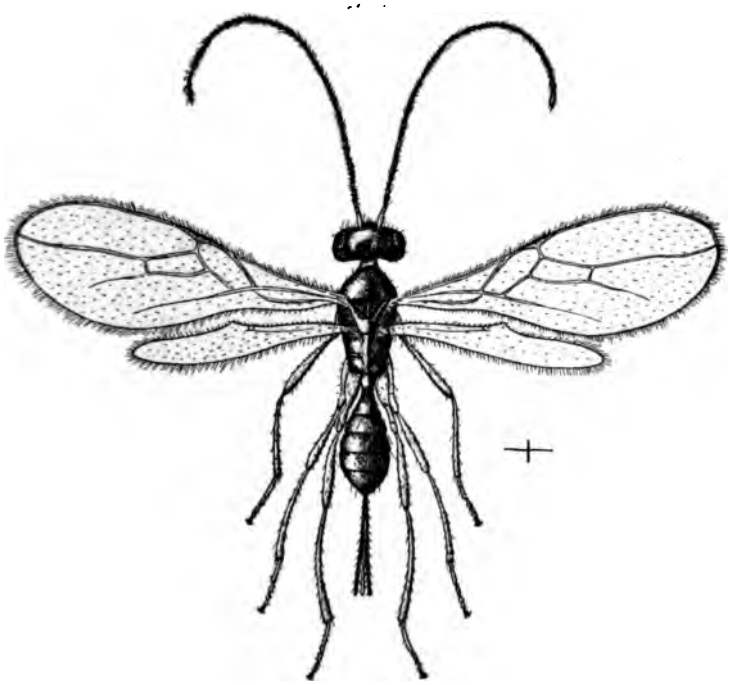

Fig. 101. *Aphœreta pegomyiœ* Brues. Female.

Thorax shining black except the prosternum which is bright honey-yellow. Mesonotum convex, without any depressions or trace of parapsidal furrows; scutellum with a long, broad, smooth fovea which extends almost across the base, divided by a median raised line; tip of scutellum behind the fovea subtriangular, strongly convex. Metanotum smooth, with a median carina and four quadrate, well-defined areas above, the lateral and pleural areas much confused. Abdomen subpetiolate, the first segment longitudinally aciculated, with two stronger median carinæ; spiracles placed near the middle, not giving rise to any distinct lateral carinæ; remainder

of abdomen smooth. Ovipositor as long as the abdomen. Legs yellow, the apical tarsal joint dark; posterior tibiæ sub-clavate. Wings hyaline, the veins piceous; stigma narrow, but of quite perceptible width. First discoidal cell and first submarginal confluent; first section of the radius one-half as long as the first transverse cubitus, and one-fourth as long as the second section of the radius; second transverse cubitus one-half as long as the first; second discoidal cell wanting.

MALE. This sex differs in having 23-jointed antennæ; otherwise noticeable differences are wanting.

This is the seventh species to be discovered in North America. It comes closest to *A. muscæ* Ashmead, from which it differs in the number of antennal joints of the male, and the length of the basal flagellar joints in both sexes. Our species may be distinguished by the following dichotomy:

NORTH AMERICAN SPECIES OF APHÆRETA.

1. Legs, first abdominal segment, and base of antennæ white ..... *pallipes* Say.
   Legs, first abdominal segment and base of antennæ yellow or brownish 2
2. Tip of antennæ white, first four joints of antennæ yellow ..... *apicalis* Ashmead.
   Tip of antennæ black, only the first two joints yellow 3
3. Vertex with a longitudinal grooved line extending from the occiput to the ocelli 4
   Vertex without such a groove, or with only the trace of one anteriorly 5
4. Female antennæ 21-jointed ..... *californica* Ashmead.
   Female antennæ 23-jointed ..... *oscinidis* Ashmead.
5. Metathorax with a strong transverse ridge, its posterior face striate ..... *auripes* Prov.
   Metathorax of a different conformation 6
6. Second section of the radius twice as long as the first transverse cubitus 7
   Second section of the radius shorter, as long as the first transverse cubitus and the first section of the radius together ..... *subtricarinata* Viereck.
7. Antennæ with the second flagellar joint almost twice as long as the first; male antennæ 23-jointed ..... *pegomyiae* Brues.
   Second flagellar joint not more than one-third longer than the first ..... *musoe* Ashmead. / *delosa* Viereck.

DESCRIPTION OF LARVAE AND PUPAE OF CERTAIN SPECIES OF PAPAIPEMA.

BY DR. H. J. FRANKLIN, ASSISTANT IN ENTOMOLOGICAL DIVISION, MINN. EXP. STATION.

Papaipema nitela Gn.

Fig. 102. Larva of *P. nitela*. Original.

Larva:

Length, 30 mm.; width of head, 2.889 mm. Head light chestnut brown in color with a blackish stripe on each side, running from the hind margin forward, and including the ocelli. Mandibles and labrum blackish. Six ocelli present on each side of the head. Scattering, rather long hairs present on the head. Body mostly pale flesh color. Cervical shield rather light brown with a blackish stripe on each side margin; a rather light longitudinal media line and a somewhat darker brown spot on each side of this line on the hind border. Dorsum of body with a narrow light, longitudinal median stripe running the entire length, from the cervical shield to the supra-anal plate. Each side of the body with a light stripe running forward from the front margin of the anal segment to somewhat behind the middle of the fourth abdominal segment, and a similar, though narrower and usually less sharply defined lateral longitudinal stripe running from the hind margin of the cervical shield back nearly to the hind margin of the metathoracic segment. Ventral side of body light, with rather dark brown legs on the thoracic segments, and a pinkish tinge on the first and second abdominal segments. Spiracles mostly black. Body naked, with scattering setæ. The second thoracic segment with one transversely elongated brown spot, and two brown seta-bearing dots behind it on each side of the dorsum. Third thoracic segment with two seta-bearing brown dots on each side of the dorsum, all in the same line across the body. Each of the first eight abdominal segments, with two pairs of brown seta-bearing dots on the dorsum, the dots of the hinder pair being more widely separated than those of the front pair. Supra-anal shield brown for most part, but somewhat blackish on the sides. Second segment in front of the anal one with two large brown spots on each side of the dorsum and the preanal segment with one large

brown spot on each side of the middle line. Most of the segments with several brown or blackish spots on each side, grouped for the most part around the spiracles where these are present.

The larvæ of this species appear to vary greatly in ground color though their stripes and other markings are apparently always about the same. The ground color is sometimes almost black, in which case the stripe on the back and those on the sides appear almost white by contrast. Sometimes the ground color is very light, so that the light stripes are often distinguished from it only with great difficulty. On specimens with very light ground color the brown seta-bearing spots on the back and sides are much more noticeable by contrast, than they are on specimens with dark ground color.

Papaipema nitela Gn.

Pupa:

Place of pupation: In stalk of Giant Bur-Elder.

Length, 20 mm. Greatest (thoracic) width, 6 mm. Wing cases tending caudad over 2-3 of the fourth abdominal segment; greatest length of these 9 mm.

Color, light chestnut brown, darker dorsad and on segment margins. Spiracles umber.

General surface smooth; the anterior dorsal margins of the third and fourth segments strongly punctate, these punctures extending caudad on each side almost to the spiracles. Fifth, sixth and seventh abdominal segments each with entire front margin punctate, this margin comprising on the dorsum about the front quarter of the segment the number of punctures diminishing ventrad. Hind margins of fourth fifth and sixth segments very minutely punctate, the number of punctures diminishing ventrad. Cremaster conical, slightly compressed dorso-ventrally and terminating in two small, slender curved spines.

Papaipema cataphracta Grote.

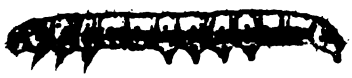

Fig. 103. Larva of *P. cataphracta*. Original.

Larva:

Length 29 mm. Width of head 2.76 mm. Body naked, with scattering setae. Head light yellowish brown in color, with a darker brown spot on each side at the hind margin. Area bearing ocelli more or less darkened. Mandibles dark brown, with blackish apices. Labrum lighter brown than the manibles. Ocelli, six on each side of the

d. Scattering hairs present on the head. Body as a whole pale
h color. Cervical shield light brown, with a longitudinal dark
wn stripe on each side, these stripes not being sharply defined
their upper sides. A longitudinal light line runs along the middle
the cervical shield. Dorsum with a median narrow, light, longi-
inal stripe running the entire length of the body from the cervical
ld to the supra-annal plate.

Each side of the body with a rather broad light stripe running
n the hind margin of the cervical shield to the front margin of the
ra-anal shield, the lower margins of these stripes being considerably
ve the spiracles. Ventral side of body light, with dark brown legs
the thoracic segments. First three abdominal segments somewhat
re pinkish than those of the rest of the body. Spiracles mostly
k.

The second thoracic segment with two setae on each side of the
sum, all four of these setae being placed in the same transverse
ne. Third thoracic segment with two seta-bearing brown dots on
h side of the dorsum all in the same transverse line across the body.
h of the first eight abdominal segments with two pairs of brown
e-bearing dots on the dorsum, the dots of the hinder pair being in
st cases smaller and more widely separated than those of the front
r. Supra-anal shield light brown with the extreme sides somewhat
ngly darkened. The preanal segment with two pairs of setae on
dorsum, those of the front pair being much more widely separated
n those of the hind pair. There are three or four noticeable brown
ts on each side of most of the segments, grouped mostly around
spiracles where these are present.

The larvae of this species vary in the shade of the ground color
ch as do those of *P. nitela,* some being very light (almost whitish),
which case the tubercles are very noticeable by contrast, and others
ng quite dark.

Papaipema cataphracta Grote.

pa:

Place of pupation, in the stem of Golden Glow.

Length, 14 mm. General color light chestnut brown. Surface
stly smooth. Widest across the thorax, measuring about 4 mm.
re. Wing cases reaching back more than half way across the fourth
dominal segment. The fourth abdominal segment dorsally, and the
th, sixth and seventh segments all the way around strongly punctate
r some distance back from their anterior margins, the punctured sur-

face reaching the stigmata on the sides of the segments. Dorsum considerably darker brown than the venter, the segments for the most part being darkest on their fore and hind margins. Cremaster consisting of a conical prominence, somewhat flattened dorso-ventrally, and bearing at its apex two small, rather slender, sharp pointed, down-curved spines. Spiracles dark brown.

Papaipema furcata Smith.

Larva:

Length, 30 mm. Width of head 2.927 mm. Head yellowish brown in color, more or less dark chestnut brown in the mouth region, and with a slight touch of the same color among the ocelli on each side. Six ocelli present on each side of the head. Scattering hairs present on the head. Body mostly pale grayish flesh color. Cervical shield yellowish brown with darker margins, and with a small dark spot on each side, placed well toward the lateral margin, about half way from the front to the hind margin. Body as a whole without stripes or other markings, except that the tubercles are large and mostly dark brown or blackish, and contrast very strongly with the ground color of the insect. (These tubercles are much larger and contrast with the color of the general body surface more sharply than do those of either *nitela* or *cataphracta*.) Tubercles located much as in *nitela* and *cataphracta*. Body naked, with scattering hairs. Spiracles mostly black. Cervical shield and supra-anal shield harder and more corneus than those plates of *nitela* and *cataphracta*. The hinder half of the dorsal portion of the preanal segment, and the outer sides of the anal prolegs also hard and corneus, and resembling the supra-anal plate somewhat in color. Thoracic legs but little darker in color than the body as a whole, much lighter than those of either *nitela* or *cataphracta*.

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THIRTEENTH REPORT

OF THE

STATE ENTOMOLOGIST

OF

MINNESOTA

TO THE GOVERNOR

FOR THE YEARS 1909 AND 1910.

SEVENTH REPORT OF F. L. WASHBURN.

AGRICULTURAL EXPERIMENT STATION
ST. ANTHONY PARK, MINN.
DECEMBER 1, 1910.

PRESS OF
H. C. BOYESON CO.
SAINT PAUL

LETTER OF TRANSMITTAL

STATE EXPERIMENT STATION,

ST. ANTHONY PARK, MINN.,

DECEMBER 1, 1910.

To His Excellency, A. O. Eberhart, St. Paul, Minn.

DEAR SIR: I herewith present the Thirteenth Report of the State Entomologist of Minnesota, covering work of this office and insect conditions during 1909 and 1910. For the sake of economy this report is now printed biennially. In addition we print from time to time and mail to farmers and fruit growers circulars of information and press bulletins, planning to have these reach them at the time when most needed, and thus be more helpful than if we delayed publishing until the issuing of the printed report. This plan appears to work satisfactorily.

GENERAL INSECT CONDITIONS DURING 1909 AND 1910: During 1909 native species of grasshoppers were abundant and troublesome in various localities throughout the state, complaints reaching this office from St. Cloud, Fertile, Crookston, McIntosh, and from localities in Otter Tail and Norman Counties. These complaints were prophetic of the trouble in store for us in 1910, the present year, in which grasshoppers have been more troublesome, causing decided loss locally, than for many years. These are native varieties, and while they have not possibly noticeably reduced the yield of grain, in the state at large, they have, in certain localities, cut down the crop of farmers from two-thirds to four-fifths, some individuals having become utterly discouraged in consequence. The output of flax, however, has been markedly diminished this year, which diminution is due almost entirely to the attacks of grasshoppers. Where practicable your entomologist has helped deserv-

ing farmers by furnishing them oil for use in hopperdozers. The furnishing of free oil, however, is too great a tax upon the slender resources of the State Entomologist, and cannot be continued unless some more material financial aid is granted by the state. It has been suggested that a grasshopper emergency fund be created, and kept upon the State Auditor's books for use in times of crisis. The trouble has come, in every case, from the existence in the neighborhood of large tracts of unused or reverted land, held by residents or non-residents, who either cannot or will not cultivate the same. The subject of grasshoppers, and the need of a more stringent grasshopper law is discussed elsewhere in this report. The greatest damage which came under our observation occurred in Wilkin County, though Polk, Clay, Norman and other counties also suffered. See page 10.

Cutworms have been so abundant and injurious during the spring of 1910 that we have made them the subject of our colored plate. Later in the season the wheat head army worm, *Heliophila diffusa,* appeared in enormous numbers in about thirty different localities, and not only destroyed the seed of timothy, but injured this crop for hay, and in many cases marched to neighboring crops, causing wide-spread havoc. This pest, which is very rarely troublesome, originated this year in Minnesota in timothy fields which had been allowed to lie too long unplowed. The army worm cited has been so injurious that it is made the subject of a special article in this report. See pages 1 and 4 and figures 1, 2 and 3 on colored plate.

The annual visitation of the different kinds of grain lice was in evidence in 1909, not resulting, however, in any serious injury.

No complaints have reached us of the Corn Root Worm which, however, is so abundant and injurious in Iowa that Professor Holden, of Ames, Iowa, reports that the 1910 corn crop of that state was damaged to the extent of $20,000,000.

Shade trees have suffered both in 1909 and 1910 from the pests common to them, and the year just closing is noteworthy on account of the quite wide-spread destruction of some of our finest city trees. Elms have been killed by the elm tree borer, and maples attacked in many cases and ruined by one or more species of Buprestid beetles which affect such trees. Both in 1909 and 1910 the Oak Pruner, the Fall Web Worm, the White-marked Tussock Moth, the Locust Borer, Bronze Birch Borer, Birch Leaf Skeletonizer, and Leaf Folders have been in evidence. (See page 103.)

The usual quota of fruit tree pests has been noted, and the increase of two scales, namely, the Oyster Shell Scale of the apple, and the Scurfy Scale, is particularly to be remarked upon. The Buffalo Tree Hopper and the Apple Leaf Hopper have also been the subjects for complaints.

We also have to report complaints of serious injury from the Strawberry Weevil. We are beginning to receive inquiries regarding the Onion Maggot and Onion Thrips. Buffalo Gnats, "Black Flies," were very bad in the spring of 1909.

A typhoid epidemic occurred in towns on the Minnesota Iron Range in the fall of 1910, and your entomologist was called upon by members of the State Board of Health to visit the localities in question for the purpose of aiding them in determining to what extent the common house fly, or Typhoid Fly, as it is now called, was responsible for the spread of the disease. An abstract of our report on conditions there, with photographs, is printed on pages 135-142.

SPECIAL EXPERIMENTS: Under the direction of the Office of Experiment Stations at Washington we have been working in 1909 with the Apple Leaf hopper, above mentioned; also a grain insect, *Macrosiphum granaria,* and a clover insect, *B. funebris,* which reduces the yield of clover seed.

Special experiments also have been conducted against the Cabbage Maggot, which attacks not only cabbage but cauliflower, radishes and turnips; against several species of stalk borer very destructive in gardens, and spraying apples and plums to prevent injury by plum curculio. We have also tested the possibility of poisoning fruit trees by the use of arsenical sprays.

Our special work in 1910 in the line of experimentation has been the study of the clover seed midge, known as *Bruchophagus funebris,* an insect which lowers our product of clover seed materially every year, probably from 40% to 50%, and whose life history is not fully understood. In this connection we are working under the direction of the Agricultural Department at Washington, and have made considerable progress in our knowledge of its habits, which knowledge will help us in combating the pest in this state. We have also carried on special experiments with various insecticides, and are beginning work with the Wheat Joint Worms.

INSECTARY: Three hundred and fourteen different experiments were carried on in the insectary during 1909. This number represents a large series in connection with the clover seed insect, referred to above, and also the leaf hopper. There has also been insectary work with the Stalk Borer, several species of borers working on shade trees, and many insects have been reared from the larval to the perfect stage, thus giving us an opportunity of studying their life histories and determining their names. Two hundred and fourteen insectary experiments is the record for 1910, which really represent a much larger number included as "sub-experiments."

EXPERIMENTAL GARDEN: A piece of land granted the entomologist for experimental work, upon a part of which the insectary is located, has again demonstrated its usefulness, and the director and a committee for the purpose has allowed the entomologist some land adjoining the present site for future work. The entomologist has been promised sufficient land for experimentation, should the present garden be needed for building space.

SPRAYING EXPERIMENTS: The assistant entomologist, Prof. A. G. Ruggles, carried on in 1909 a number of experiments in spraying, and in summarizing the results of the work, it may be said with certainty that three sprayings for plums and apples, with three pounds of arsenate of lead in fifty gallons of Bordeaux mixture, the first spraying to take place before the fruit trees bloom, the second just after the bloom has fallen, and the third ten or twelve days later, will insure a very large per cent of sound fruit, protecting the fruit and the tree from the attacks of the Plum Curculio, Codling Moth, and also a majority of plant diseases. See page 143.

The crop of plums and of apples was practically a failure in 1910, and we have, therefore, been unable to push work further in this direction.

STATE INSECTICIDE LAW: At the thirty-sixth session of the State Legislature a bill, (H. F. 173) for an act to prevent deception in the sale of Paris green and other insecticides, introduced by Mr. Horton, became a law. The enforcement of all provisions of the act was placed with the State Dairy and Food Commissioner. A federal law to the same effect, but including all states and territories was created by Congress in the same year. The latter also imposes several penalties for the shipment of any adulterated insecticide or fungicide. See page 101.

CORRESPONDENCE: During 1909 the entomologist dictated 2,149 letters, in large part answers to inquiries regarding insect pests. In addition 774 circular letters were mailed, and about 2,000 circulars and press bulletins, exclusive of the station mailing list. This does not include the Twelfth Report, which was sent out to approximately 700 addresses in addition to copies mailed to comply with individual requests. Bulletin 112, which was practically a duplication of the Twelfth Report, was sent from the Experiment Station mailing office to something like 15,000 addresses. In 1910 we mailed 2,461 letters, answering inquiries, in addition to over 1,000 circulars.

LECTURES: In 1909 a few lectures were given by the entomologist in the northern part of the state (notably one on December 1st to farmers at Red Lake Falls) in regions which had suffered that year from attacks of grasshoppers. In 1910 one lecture was delivered January 14th at Duluth, and lecture appointments for the next eight weeks have already been made, as follows: December 6th, State Horticultural Society, Minneapolis; December 12th, Boy Scouts, Minneapolis; December 21st, Agricultural College, Crookston; December 28th, Entomological Society of America, Minneapolis meeting; January 21st, Boys' Club, Minneapolis. Lectures were given, both in 1909 and 1910, to students in the Farmers' Short Course at the Agricultural College.

Publications.

—1909—

Jan. 20—"Cabbage Maggot on Radishes, Work of 1908."

Feb. 12—Twelfth Report of State Entomologist, "The Apple Leaf Hopper and Other Injurious Insects of 1907 and 1908".

Feb. 20—Circular No. 16, "San Jose Scale Possibilities in Minnesota".

May 4—Press Bulletin 31, reprint, "Suggestions to those contemplating spraying".

May 25—Circular No. 17, "Household Insects: A, The House Fly and the Clothes Moth".

Nov. 15—Circular No. 18, "The Museum of the Division of Entomology at the Minnesota Agricultural College".

—1910—

Feb. 1—Circular No. 19, "The Danger of Introducing the Gypsy and Brown-tailed Moths into Minnesota".

April —Nine thousand insect charts.

June 1—Vol. 1, No. 1, Minnesota Insect Life.
July 1—Vol. 1, No. 2, Minnesota Insect Life.
Aug. 1—Vol. 1, No. 3, Minnesota Insect Life.
Aug. 25—Press Bulletin No. 39 (Circular No. 20), "Grasshoppers and Army Worms in Minnesota".
Sept. —Pamphlet descriptive of figures on chart "Some Minnesota Insects and Useful Birds".

NURSERY INSPECTION: In 1909 sixty-two nurseries were inspected; the sum of $234.74 collected as legal fees and expenses was turned into the State Treasury, according to law. In 1910 fifty-eight nurseries were examined, much more time being spent on each nursery than in the preceding year. The sum of $263.73 received, was handed the State Treasurer, and receipt received therefor. See page 59 for detailed account of inspection of nurseries.

INSPECTION OF STOCK IMPORTED FROM EUROPE INTO MINNESOTA. See page 59.

INSECT CHARTS ISSUED BY THE STATE ENTOMOLOGIST TO THE PUBLIC SCHOOLS OF THE STATE. See page 123.

SAN JOSE SCALE. See page 67.

INSECT COLLECTIONS; HYMENOPTERA OF MINNESOTA: Our collection of Minnesota insects has been materially increased this year, and we have made a special effort to secure a systematic collection which will aid in a popular treatise on the bees, ants and wasps of Minnesota planned by this department.

"MINNESOTA INSECT LIFE": This publication is a new feature of our work. It aims to place before farmers and fruit growers of the state *timely* items on the prevention of insect injury during the spring and summer. The mailing list of this publication is growing constantly. It is in no sense a bulletin. We issued this year three numbers—one on the first of June, one on the first of July, and one on the first of August. We aim, in future, to mail the first copy not later than April 1st, which will, among other things, give our agriculturists proper information regarding spraying.

EXHIBITS: In March, 1910, at the first State Conservation Congress, held in the Auditorium at St. Paul, this division displayed an instructive collection of insect models, illustrations of insect injury, life histories, spraying machinery, nozzles and insecticides.

The entomologist was in Europe at that time, and the exhibit as prepared and installed by Assistant Professor Ruggles of this partment. We also had, as in previous years, exhibits at the tate Fair both in 1909 and 1910.

HONORARY OFFICES: During 1909 and 1910 the Minnesota ntomologist has held the office of President of the American ssociation of Horticultural Inspectors, and has recently been hon-ed by being elected President of the American Association of conomic Entomologists for the ensuing year.

ACKNOWLEDGMENTS: The work of the past two years has en materially helped by the faithfulness and efficiency of my fice force and field assistants. I wish to express my appreciation their loyalty. I have lost one good man in Dr. Franklin, who signed to accept an extremely flattering offer in Massachusetts. is place has been filled by Mr. Theodore Urbahns, formerly in overnment service, who comes to us with excellent recommenda-ons. Mr. A. G. Ruggles is still with me as chief assistant. Mr. W. Stafford has been employed in the insectary. The state ess, as always, has been helpful in placing before the public timely tices regarding insect pests. While this department does not sitate to publish what it deems important, we greatly deplore the actice prevalent among many reporters of writing up ficticious cares" for the sake of making good stories. As exhibiting the lp of the press in connection with our work, and also showing in at demand publications from this department are, when it is nerally known that such publications are for distribution, this ice received, after inserting notice of publication in various county per, but by no means in all, over five hundred requests for a lletin on spraying, within a period of six weeks.

In connection with our inspection of European nursery and rist's stock sent to this state, the collectors of U. S. Customs, both St. Paul and Minneapolis, have been very helpful in that they ve notified us immediately upon the arrival of foreign shipments. e page 59

Finally, I wish to thank you, Sir, as well as others at the State pitol, for most courteous and kindly treatment in connection with work of the entomologist.

Respectfully,

F. L. WASHBURN.

FINANCIAL STATEMENT,* FISCAL YEAR, AUGUST 1, 1908, TO AUGUST 1, 1909.

Apiary supplies	$ 15.99	
Assistant Entomologist (salary)	466.64	
Clerk and accountant	400.00	
Cuts, etchings, electros, colored plates, etc., for Annual Report, bulletins and circulars	423.82	
Drawings, etc., for reports, bulletins and circulars	79.49	
Experimental garden supplies	104.99	
Field notes on insects	25.41	
Field and traveling expenses of Assistants	207.73	
Freight and express	73.62	
Insectary apparatus	26.55	
Insectary and field assistants	364.36	
Insecticides	33.87	
Labor	152.99	
Laboratory supplies and apparatus	82.07	
Microscopes (Greenough dissecting) for insectary	222.00	
Models of insects for lectures, and insect cases	42.50	
Nursery inspection expenses	214.91	
Office and laboratory assistants	306.90	
Office supplies and furnishings	74.77	
Periodicals, publications, library cards, etc	147.31	
Photo supplies	75.99	
Plants for experimental garden	49.90	
Postage Correspondence, Biennial Report Circular	156.00	
Printing Annual report, circulars etc	1,008.25	
Spraying machinery	18.00	
State Entomologist's traveling expenses	156.47	
Stationary, etc	91.35	
Substitute stenographer	22.50	
Telegrams	13.08	
Telephone	65.00	
	$5,122.46	$5,214
Credit Nursery Inspection		$ 214
Entomologist's Fund		5,000
		5,122
Balance on hand		$ 92

*Bills covering details of the above are on file in the State Auditor's Offi

CIAL STATEMENT* FICAL YEAR AUGUST 1, 1909 TO AUGUST 1, 1910.

.....	$ 13.25	
ntomologist (salary)	1,649.99	
ntomologist, (Traveling expenses)	70.32	
l Federal Inspection	135.00	
gs, etc., for Press Bulletins and Circulars	11.39	
r rep. buls, circulars, etc	35.00	
d Freight	40.82	
.....	36.50	
ssistant (field expenses)	104.60	
ief (field expenses)	84.55	
upplies	30.02	
.....	33.54	
r combating grasshoppers	6.00	
.....	131.47	
supplies	203.03	
.....	8.56	
spection	202.31	
ants	151.52	
ies	32.35	
atives, prints, etc	33.79	
garden	52.85	
ulletins, circulars, etc.)	44.75	
, periodicals, press notices, etc	109.24	
nd clerk	1,001.00	
achinery	311.00	
correspondence, circulars, etc	69.00	
.....	103.58	
stenographer	10.00	
.....	18.59	
.....	60.00	
xpenses	209.35	
	$5,003.07	
on hand Auggust 1, 1909		92.45
.....		$5,000.00
inspection		234.74
		$5,327.19
		5,003.07
on hand		$ 324.12

overing details of above on file in the State Auditor's Office.
ve account has been examined by me and found correct.

Samuel G. Iverson

State Auditor.

J. L. WOOD, DEL.

CUT WORMS, ARMY WORMS, AND OTHERS.

INJURIOUS INSECTS OF 1909 AND 1910

BY F. L. WASHBURN.

CUTWORMS.

EXPLANATION OF PLATE:

Figs. 1 and 2—Wheat-Head Army Worm, *H. diffusa*, Walk., much enlarged, and showing variations in color.

Fig. 3—Moth of the same.

Figs. 4, 5, 6 and 7—Different Cutworms, collected in the vicinity of St. Anthony Park; died before reaching maturity, hence not identified.

Figs. 8, 9 and 15—Caterpillar, Moth and Pupa of *Hadena devastatrix*.

Figs. 10 and 11—The Zebra Caterpillar, or Painted Mamestra and its moth, *Mamestra picta* Harris.

Figs. 12, 13 and 14—Larva, Moth and Pupa of the Cutworm known as the Subgothic Dart, *Feltia jaculifera*.

We are indebted to Dr. J. B. Smith for identification of the above imagoes. Riley's account of *H. alblinea* probably applies to *H. diffusa*, the latter being commonly regarded as *albilinea* and was so figured by Riley.

Cutworms, represented here by several species, have been so extremely troublesome in 1910, that we have made them the subject of a colored plate in this report, including also the Wheat-Head army worm, *Heliophila diffusa*, Walk, which has been locally very destructive, and also the Zebra caterpillar *Mamestra picta*, and its moth; which, while not a cutworm in the strictest sense, belongs to the same family, *Noctuidae*.

The abundance of cutworms this year may have been due, in a measure, to the cold weather cutting down the weed growth which started in the abnormally warm weather of the early spring of 1910, obliging them to turn their attention more completely to cultivated crops. Complaints of cutworm injury began to reach us in May of the present year, and a few letters were received as late as August. There were more than twice as many complaints in 1910 as in the preceding year, and among the localities affected were Brainerd,

Atwater, St. Paul, Ada, Hibbing, Hastings, Grove City, Kimball, Duluth and Sauk Center; showing the generally unusual distribution of these pests over the state. Several species were probably responsible for the injuries. Those shown upon our colored plates were, for the most part, numerous; but they by no means represent all the varieties present during the two past years.

Two instances well illustrate the unusual abundance of this pest in 1910: A gardener in Minneapolis brought us something like fifty or sixty cutworms (species not determined at the time) which he had dug from the soil along a row of onions, not more than fifty feet long; while a member of our staff dug up from about a small piece of golden glow, not more than two feet square, last spring, thirty to forty cutworms.

Cutworms are the larval forms of moths belonging to the family known as *Noctuids,* or Owlet Moths. The first name was given this family because they are particularly night-flyers, most of them remaining concealed during the day; and the second name, on account of the fact that their eyes shine at night, in the presence of a light, to which, by the way, many of the species are attracted. Living normally in sod land, what could be more natural than that when deprived of this by farm cultivation, they should attack the crop immediately following. They may be, therefore, very severe on crops following sod. The larvae, like the moths, work at night, and conceal themselves, either in the ground an inch below the surface or under some protecting material, in the early morning. Both the moths and their larvae are fond of sweets; and this fact is made use of both by collectors in catching the moths and by the farmer and gardener in killing the "cutworm" itself. The larva, when full grown, averages in length about one and one-half inches, and is, as a rule, dull colored, with or without obscure markings (see colored plate). This full-grown larva burrows into the soil a short distance, and turns into a brownish or reddish-brown or mahogany-colored pupa (see Figs. 14 and 15, colored plate). These pupae may winter over, when formed late in summer, or give rise to moths in August and September, which lay their eggs at that time on various plants, or on the ground near their food-plants. The larvae which hatch in late summer or fall, winter over in some concealed situation, and are ready for business in the spring.

While many birds prey upon cutworms—and although they are eaten by some other insects, and are the victims of parasitic forms, to say nothing of diseases bacterial or fungoid—nevertheless we

have to take active means to combat them if we wish to save our crops. This division has found poisoned bait, made of bran mash sweetened with cheap sugar, or syrup, or molasses, and made decidedly green with a liberal application of Paris green, to be a very good remedy in a garden. A tablespoonful of this should be put at frequent intervals among the plants subject to attack; not, however, nearer than twelve inches to the plant; for, in case of rain, the Paris green might be washed against the roots, and would injure or kill the plant. The Paris green should be mixed with the bran when the latter is dry. Thorough cultivation is an aid. Pieces of shingle or board, placed at intervals over the garden, serve as traps under which the cutworms hide toward morning, and enable them to be found and killed. Frequently the depredator will be found in the morning, within an inch or so of the plant cut, buried an inch under the soil. Young plants, when not too numerous, like cabbage, cauliflower, etc., when first set out in a small garden, should be protected by paper or tin, or a barrier of some sort, which should extend into the ground an inch or so, and two or three inches above the surface. This can be removed when the plant becomes so tough as not to invite attacks from the cutworm. On large acreages, fall plowing and thorough cultivation is perhaps the most practical treatment. Cutworms, as we said above, are always bad the next year after sod, since they normally live in such situations. Some farmers, in 1910, reseeded their grain fields with flax on account of the former being destroyed by cutworms.

The family *Noctuidae* is an enormous one. Professor Lugger, my predecessor, left a list of two hundred and thirty-five different species of the group, captured partly at St. Anthony Park, and partly at Duluth. Of this list, something like forty-five species are typical cutworms. Therefore, farmers can hardly speak of "the cutworm."

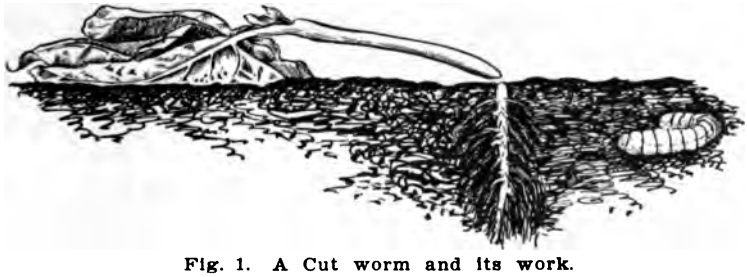

Fig. 1. A Cut worm and its work.

A WHEAT-HEAD ARMY WORM.

(*Heliophila diffusa*, Walk.) An Enemy of Timothy.

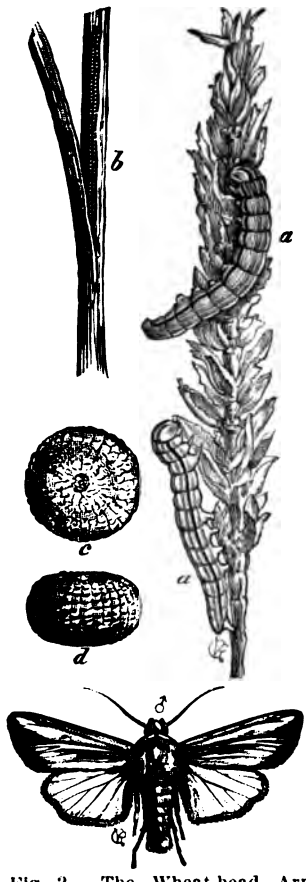

Fig. 2. The Wheat-head Army Worm. *A. diffusa*, *a*, *a*, worms feeding on head of grain; *b*, eggs under a leaf sheath; *c*, *d*, two views of egg, enlarged. Below, the male moth. After Riley. Courtesy of J. B. Smith.

About the first of July of the present year the note of alarm in connection with this unusual visitor was first sounded by a telegram received from Detroit, Minn.—"Worms damaging corn and grain badly here. Please send man to investigate." July 5th came another one from Heron Lake—"Green worms working on wheat, oats and rye. Send man to introduce method of extermination. Condition serious." Following these, and all in July, came complaints from Russell, Canby, Walnut Grove, St. James, Elbow Lake, Windom, Cottonwood, Revere, Marshall, Worthington, Hills, Tyler, Battle Lake, Ashby, Murdock, Stillwater, Ruthton, Hendricks, and elsewhere.

Men were of course dispatched, upon receipt of the above telegrams, to the places asking for help; and we were kept busy during midsummer in going from place to place and doing what we could to instruct farmers in the methods necessary to overcome the trouble. We found in every instance that the original infestation came from old timothy fields —fields that had been allowed to stand for from six or seven to ten years without feeling the plow, and offering ideal conditions for the increase of the pest. It is probable that this army worm was present and increasing in 1909, though its numbers at that time were not sufficient to attract the attention of the farmers. The drouth of 1910 was probably also in part responsible for the devastation of the current year.

These army worms (see Figures 1 and 2 of colored plate) vary in color from green to a very dark brown, or even blackish, but almost invariably show characteristic stripes on sides and back.

e a quite different species from the army worm which is to the majority of Minnesota farmers. *H. unipuncta*, ch is commonly known as "The Army Worm."

The Wheat-head Army Worm, the species under discussion as causing damage this year, is not a frequent visitor in Minnesota, or anywhere else for that matter; and it may be many years, barring its possible occurrence in small numbers in 1911, before we are troubled by it again. It is widely distributed over the United States, as far west as the Great Plains. When full grown, at which time the caterpillar is about one and a fourth inches long, they go into the ground two or possibly three inches, and turn into mahogany-colored pupae about three-fourths of an inch long, resembling closely Fig. 14 of the colored plate, from which the pale brownish or "clay yellow" moths (Fig. 3 of colored plate) emerge later. The female moth lays its eggs on the leaves (timothy, grasses, grains, etc.); which eggs hatch into the above-named worms. We found many of them entering the pupal stage shortly after the middle of July; hence it would seem that it is two-brooded, or at least partially so in Minnesota; but it would appear that the second brood of worms, coming late, after harvest, might meet with difficulty in finding food.

It is not out of the way to say that at least four-fifths of the timothy seed crop in central and southern Minnesota has been destroyed this year by this species of army worm, and the timothy materially injured as a hay crop. A conservative farmer near Marshall, estimated the loss on the hay alone as equaling one-fourth of the crop, or a loss of about $2 on every acre. In the vicinity of Otter Tail, it was roughly estimated that they had nearly destroyed 200 acres. Around Battle Lake, about 1,000 acres were badly damaged. A farmer at Windom states that he lost $150 on his timothy crop. From Russell we received a report that from 1,200 to 1,500 acres of timothy was practically destroyed. From another section, 95 acres of timothy was reported as a total loss. A statement received from Heron Lake (July 13) was to the effect that the

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head
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Fig. 4. Head of barley injured by Wheat-head Army Worm. Original.

seed of 75 per cent. of the timothy acreage destroyed. From St. James, same date: ' is entirely destroyed, absolutely worthless Timothy crop has been damaged from 20 to 25 per cent for hay. Timothy will (three-fourths to one and one-fourth tons p From Tyler, "The timothy crop of seed in tion is practically all gone * * * and we get is short and thin." From Wind 15th, "Twenty acres (of timothy) are a to About July 7th, A. T. Sexe, near Hills, that this army worm had about compl stroyed his forty-acre field of timothy. U of August 27th, 1910, Northrup, King & letter to the entomologist, in which they the serious loss in sections where mos timothy seed is harvested, state that timc had nearly doubled in value. This, howe in a large measure due to the drouth of l mer. Conditions practically identical with Minnesota prevailed in parts of Iowa and kotas.

Mr. Urbahns was sent to Worthingto July 12th. He found army worms had dc damage to timothy by feeding upon the hea injury was most severe on high sandy s larvae were rapidly pupating on above c their work for the season was over. He farmers more or less interested in the c this pest, and carried on discussions concern bative measure.

In every case investigated, as stated a found that the pest had its origin in old fields that had been allowed to run a n years, four or more, without being plowe the timothy heads are eaten, the worms t attention to oats, wheat or corn, travelir army from one field to another, hence their

They appear to be somewhat subject t tacks of parasites; and are undoubtedly, in with other caterpillars devoured by p

eetles, by birds, and die on account of fungous or bacterial diseases. Nevertheless, these factors simply serve to keep them within bounds, and it is absolutely necessary, when a farmer is confronted with a horde of these worms stripping his timothy field, and preparing to march to grain fields, to know what to do ,and to realize that *whatever is to be done must be done without delay in order to be effective.* Fall plowing and the rotation of crops, sovereign remedies for many field-insects, are valuable here. If farmers would plow up their timothy fields at least once in three years, it would be a help in connection with this or any other insect which found there an undisturbed breeding-ground. Another year, quite possibly, this army worm might not originate in timothy, but be found beginning its depredations on some other crop. Its repression, therefore, appears to be dependent upon proper farm practice. In cases of serious infestation, as in the present instance, when a farmer's crop is threatened by these worms, and the land is in a condition to allow it, he should plow one or two deep furrows across the line of march of the worms, the steep side of the furrows toward the crop to be protected. The worms collect in the furrows and can be killed with kerosene, or better, with crude oil. If post-holes eight or ten inches deep are made at intervals in these furrows, they form traps into which the worms fall. Or, the ditch or furrow may be partially filled with straw, which may be wet with kerosene and burned after the worms have collected thereon. A farmer can spray a broad strip about the worms, or across their line of march, with Paris green, at the rate of two or three pounds in 100 gallons of water; or arsenate of lead (better than Paris green) at the rate of four or five pounds in 100 gallons of water. Sometimes it is practicable to drag a heavy roller over the advancing worms. Dusting dry Paris green on vegetation about the worms may be resorted to. Fields where they are entering the soil to go through the resting stage should be plowed—harrowing is not sufficient. Co-operation in the attack is necessary; for there might remain on one man's place enough worms to lay waste the entire neighborhood later on, if every one did not take preventive measures.

The presence of this worm on cured hay does not poison it for stock, as some farmers have supposed.

From July 11th to 13th, Mr. F. J. Crider of this division was in the field. His report in detail follows:

CONDITIONS AT WORTHINGTON: I was taken out into the field around Worthington by Mr. Jones. Spent half a day in this way; talked to several farmers of the community in *regard to* the work of the army worm. Dam-

age from the insect was confined entirely to timothy; did not go into grain. The seed crop of timothy was a total loss. Most farmers cut the timothy for hay, but state that its hay-value was greatly lessened by the work of the insect—20 to 30 per cent was the average estimated loss on hay. The worm not only destroyed the head, but in many cases stripped the plants of their leaves. The greater amount of damage was reported from *old* timothy fields that have not been broken in from five to ten years. Some farmers did not use their hay for any purpose, but left it standing in the fields. It now presents the appearance of naked stems, destitute of heads or leaves. I searched, and found several live pupae just beneath the surface of the ground; but the majority of the insects seemed to have already changed to the adult stage, as was evidenced by the great number of empty pupal cases that were found. I counted as many as a half-dozen empty pupal cases in an area of sod six inches square, and among those only one live pupa. On the whole, however, there are yet a great many pupae still in the timothy sod.

Mr. Jones is very much interested in the work of eradicating the army worm. He expressed a willingness to co-operate with the Station in any way possible. Says that he shall be glad, and wants to bring the farmers in closer touch with the Station, in a way that will benefit them. He will distribute literature, etc., among the farmers of the community, if such is desired.

CONDITIONS AT WINDOM: Called on Mr. Brown, County Auditor; talked with several farmers of the community, and went out into the fields around Windom. About the same conditions were found as at Worthington. From the standpoint of seed, the timothy crop is a total loss. Most farmers have cut the fields for hay, but state that its value was greatly lessened by the work of the worm. No damage was reported concerning grain-fields. The work of the insect was confined to timothy alone. Found some live pupae in the fields in timothy sod, and a great many pupal cases, showing the adult had already emerged. Mr. Brown was very pleasant, and wished to render the Station any assistance possible.

CONDITIONS AT ST. JAMES: Went out to Mr. Otto Uhlhorn's place; walked through the fields all the way out. Mr. Uhlhorn and other farmers stated that the damage from the army worm was confined to timothy, except on the edges of grain-fields adjoining timothy. The timothy crop is a total loss for seed, and 25 to 30 per cent loss for hay. Most farmers used the crop for hay, a few fields were not cut at all; fields of old timothy sod were damaged worst. New timothy fields, near old sod, affected worse than entirely new fields or fields away from old sod. Insect appeared when timothy came into blossom, and remained until the crop was destroyed. Heard of one man at Darfur, seventeen miles from St. James, whose oats were attacked to some extent by the insect. Charley Stark, Mountain Lake, had a field of timothy for seed, that was entirely stripped by the 17th of July.

Looked for pupae in the fields, and found the same conditions as at Worthington and Windom. Several live pupae were found, but mostly abandoned pupal cases.

Mr. E. W. Stafford was sent to Heron Lake on July 6th, and makes the following report:

Examined conditions at Heron Lake. Army worms have been working on timothy which is becoming mature and being cut. They now are migrating to other crops, e. g., wheat, oats, barley, corn. These larvae have destroyed most of the timothy seed in the environs of Heron Lake. As timothy is ready to cut, maximum damage is already done to that crop. Rye is much of it cut, so not damaging it. One farmer's oats so badly infested that he cut prematurely for hay. Recommended plowing furrows and use of kerosene and crude oil. Placed larvae on kerosene can almost dry; died in 45 to 60 seconds. Examined field of corn belonging to Mr. Pratt; across road, a badly infested timothy field, on farm of Mr. Smith. On farm of C. P. Fiske little infestation. In Pratt's field the rows near timothy were badly infested with army worms. Attacked central shoots, ate holes in leaves, and ate on edges of the leaves. Degree of infestation decreased as one advanced away from edges of field. After about 35th row, little or no infestation. Looked at corn rather late in the evening, and found many larvae on the ground. It rained the day before examination was made, and Mr. Fiske said larvae on his oats were not as plentiful as the day before.

Visited the farm of Mr. Geo. Reynault, and found army worms migrating from cut timothy to other crops. Attacked oats, wheat and barley equally badly. At edge of fields, found great numbers; ten feet in, found a few, and at thirty feet found none at all.

It is said that some timothy fields have been left as long as ten years. Where there was no timothy there was no trouble with the worm. Much of the grain will soon be harvested, so will be out of danger. Many farmers are enthusiastic about the idea of using crude oil in the furrows. Price is lower, and it will not evaporate so readily nor penetrate into the soil.

The worms do more damage to wheat than to other crops, as they often cut off stems at base first thing, then the whole head falls off. In oats, the larva consumes one kernel at a time. I did not find any on flax, clover, alfalfa, nor on the swale grasses.

Went out with P. B. St. John to farm of John Maxner. Timothy being cut, corn adjacent. First forty rows rather bad. He had put Paris green on two rows, with little or poor results. I examined the stubble for larvae, but found none.

Went to Shaeffer's farm. He had cut a furrow about two feet from edge of field, and left strip as trap. This got covered with larvae, and with a pail he collected a large quantity, which he killed.

The Wheat-head army worm.

GRASSHOPPERS.

During the summer of 1910 grasshoppers have worked more havoc than for years before. Numerous complaints were received in 1909, but it would seem that these complaints merely indicated that the "hoppers" were gathering their armies, as it were, and preparing to work all the havoc they could in 1910. The accompanying map indicates by crosses the counties from which complaints regarding grasshoppers were received during the above-mentioned two years, and also the number of localities in each county from which we received inquiries; by far the largest number representing complaints sent in during the season just passed. These crosses represent by no means the entire number of inquiries or reports of injury, since in almost every case many complaints came from one town. The circles shown mark localities suffering in 1910 from the attacks of the Wheat-head Army Worm.

Fig. 5. Map of Minnesota. Crosses show localities from which complaint was received of grasshopper injury. Circles denote localities reporting Army Worm injury.

With all due appreciation of the help given this division by the state press, perhaps no insect is used more than the grasshopper, by ambitious young reporters, to make a good story with scare head-lines. What made it more aggravating in this instance was the continual confusing of the Seventeen-year Locust or "Harvest Fly"—which is a sucking insect and not a true locust or grasshopper—and the grasshoppers or true locusts, which have been so unpleasantly prominent this year. To illustrate, we quote one or two absurd statements from county papers. The Tribune of Stewart, Minn., under date of August 19, 1910, says:

"But within the past week several farmers have seen the genuine *red-legged, Seventeen-year, or Rocky Mountain locusts flying high in the air.*"

On January 19, 1910, the Standard, of Albert Lea, had some reference to a visitation of Seventeen-Year Locusts. The entomologist, in a desire to straighten the matter out. sent a letter to the editor. Note how the editor treated it in his issue of February 2, 1910:

Figs. 6 and 7. Cicada or Harvest Fly, commonly called locust, and a true locust, commonly called "Grasshopper."

"No Fear of Grasshoppers."

"The Standard is in receipt of the following letter, which ought to dispose of all predictions and guesses concerning the pest mentioned."

"EDITOR STANDARD: I note, that in your issue of January 19, you have reference to the coming of the Seventeen Year Locust. No prediction r garding this insect has gone out from this office at any time; and, as yc say, quotations of this kind are frequently unfulfilled. It seems a pity th things of this sort are spread over the country, unnecessarily alarmi citizens, and causing more or less of a reflection upon the entomologist.— I. Washburn, State Entomologist."

There is no prospect at present of an invasion of the Periodic Cicada or Seventeen-year Locust, though many states to tl south and southeast of us have periodical appearances of this i sect, which passes the seventeen years (or thirteen years in tl case of the 13-year form) of its larval life in the ground. It is n out of place, perhaps, to take this opportunity to advise farmers avoid accepting unauthorized statements regarding insects, appea ing in the daily or county papers, and to read most carefully a communication *authoritatively signed;* for sometimes, as in tl above example, the heading and the information contained in tl letter are quite at variance.

One will note, upon looking at the accompanying map, th grasshoppers were pretty well distributed over the state in 19(and 1910, drawing this conclusion from reports and complain received through the mails, but that they became much more n merous, and consequently much more destructive, as one we west and northwest from St. Paul; and that in the Red River Va ley, throughout its entire length, they were particularly sever These are all native locusts or grasshoppers, as we all call the as far as seen; and, when they are bad at all, loss is bound to l felt in the area indicated. In other words, in a farming locali which one might call a pioneer region, in that it is in the imm diate vicinity of large tracts of untilled land, we will always ha times of more or less trouble with grasshoppers.

Although the yield of flax has been materially reduced, t entomologist does not believe that the entire output of grain Minnesota has been materially diminished in 1910 by this yea attack. But that is not the point at issue at present. The fact tl

many of our hard-working and deserving farmers in the counties indicated have lost materially, anywhere from a fifth of a crop to their entire crop production, and that some are so thoroughly discouraged as to think of abandoning farming in Minnesota, should interest state authorities sufficiently to cause them to inquire into the reason for these periodical invasions, and find a remedy. The reason is not hard to find. Large tracts of land which have reverted, or which have never been cultivated, held by speculators or others, offer ideal places for the egg-laying of this pest; and there are thousands of acres of such land in the western part of this state, where owners are absolutely indifferent to the fact that farmers, endeavoring to make a living on the outskirts of these pest-breeding acres, have to make prodigious efforts to secure crops, and frequently fail altogether, because they cannot cope successfully with the hordes of grasshoppers pouring in upon them from the above-mentioned uncultivated acres. We have a grasshopper law in this state; but, inasmuch as the owner or lessee of such dangerous land is not obliged by this law to pay for the plowing, it is ineffective. We have the names and addresses of many of the owners or holders of such land, and a list of their property in Wilkin County; and have written some, only to find—knowing as they do, the weakness of the law—absolutely indifference, carried to such an extent in one or two cases that they did not even take the trouble to answer our letters. There are thousands of acres of such land in Wilkin County alone—the undisturbed breeding-ground of millions of grasshoppers. In Andrea Township alone we have a record of over 8,000 acres of such land. Manifestly a county cannot stand the expense of plowing these tracts, even if sufficient men could be secured to properly do the work.

Two ways are open, which would seem to offer at least partial relief for this deplorable situation; one, the work of the individual farmer, properly directed by experts, aimed at keeping the hoppers off his growing crops, and to that end using intelligently not only well known methods, but others which may be discovered through investigations of entomologists; and second, the creating

of a more stringent law—something like the grasshopper law of North Dakota, perhaps,—obliging large land-owners to bear the expense involved in fighting this insect. We are heartily in favor of such a law for this state. We want also to have, for the next two or three years, an expert in the field constantly, located at a central point in what we might call "the grasshopper district," and not only trying various new methods available for the farmer, some of which we have in mind at present, but also going from place to place where needed by farmers, and instructing them how to properly apply the best known measures of protection. Such a man would be immensely useful to farmers in a stricken locality, beside being in a position, from a constant careful study of the situation, to make valuable suggestions along new lines of control. Further, we have recommended to the Governor and the State Auditor the advisability of keeping upon the Auditor's books a sum which does not revert, but is always available in times of crises, to meet emergencies along these lines. For a time there was such a fund, consisting of several thousand dollars, left over from early grasshopper days. This has reverted long since, and at present there is absolutely no fund to draw upon if we ever have a sudden and destructive visitation of grasshoppers. The writer has suggested that a fund of from $12,000 to $15,000 be kept upon the books, for emergency use only, and its expenditure properly safeguarded by a board or commission. This plan has met with the approval of the State Auditor, who states that he sees no reason why such a bill would not receive the approval of the Legislature.

In April of the present year (1910) a report was received, from a farmer living at Granite Falls, that the unusually warm weather in March had brought out the young grasshoppers, and that they had been killed by the freeze in April. This would have been good news if it had been actually the case in all parts of the state. Unfortunately, grasshoppers were found hatching in large numbers early in May, when all danger of cold weather had passed; and our hopes, based on earlier reports, if we had such hopes, were doomed to disappointment; for, in the eight years and more we have served Minnesota, we have never had so much trouble and so much complaint as in 1910. Twenty or more afflicted farmers in Wilkin County were in correspondence with this division on account of this trouble, and we have had men in the field assisting them, showing them how to construct and use hopperdozers.

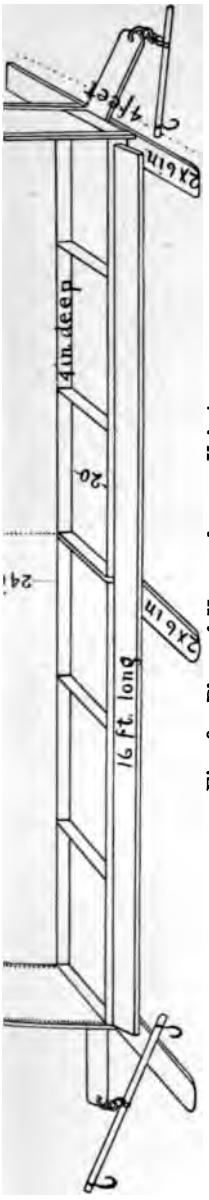

Fig. 8. Plan of Hopperdozer. Urbahns.

North of Wilkin County, near Crookston, Fertile and Beltrami, and also in Otter Tail County and elsewhere, practically the same conditions existed. In some cases we furnished oil free to farmers, for use in hopperdozers. There is no law directing the entomologist to do this, but he looked upon the existing conditions as an emergency, and wished to do all he could to assist men endeavoring to raise crops under these trying conditions. Perhaps fifty hopperdozers were in daily use in one neighborhood in Wilkin County.

Letters complaining of grasshoppers began to reach our office early in June, rapidly increasing in numbers during that month, and continued arriving in large bunches until late in August and even into September; and this division of the Experiment Station was kept busy, both in visiting different localities and in correspondence.

We mentioned above the furnishing of free oil to needy farmers who required it for hopperdozers (see account below). In this connection it should be said that the State Entomologist's fund is not sufficient to meet any such demand, and particularly would this be the case if we were deluged with the pest. It is to be hoped, therefore, that some special legislation may be enacted this winter, covering the needs in question.

KEROSENE ALLOWED FARMERS FOR COMBATING GRASSHOPPERS IN 1910.

June	18	W. W. Rowles, Everdell	25	gals.	$ 3.25
June	18	W. & F. Fuder, Foxhome	23½	"	2.94
June	23	Chas. Reber, Foxhome	50	"	6.25
June	24	F. E. Sutter, Foxhome	10	"	1.25
June	24	H. J. Marsh, Foxhome	5	"	.63
June	25	T. S. Olson, Foxhome	18	"	2.25
June	26	Henry Hendrickson, Everdell	25	"	3.25
June	27	P. Stonehart, Rothsay	45	"	5.85
July		A. M. Gamme, Beltrami	20	"	3.00
July		C. K. Lukman, Beltrami	25	"	3.75
July		B. O. Lindberg, Beltrami	20	"	3.00
July		F. W. Lenz, Beltrami	20	"	3.00
July		C. Nordlum, Beltrami	20	"	3.00
July	6	O. K. Bjerkebek, Breckenridge	10	"	1.50
July	8	O. K. Bjerkebek, Breckenridge	10	"	1.50
July	9	Ole Toso, Rothsay	15	"	2.25
July	9	Nils Sudahl, Rothsay	20	"	3.00
July	11	Boyer Bros. & Co., Beltrami	15	"	2.25
July	11	Phil. Heider, Foxhome	20	"	2.50
July	13	F. M. Hunter, Breckenridge	25	"	3.75
July	29	A. Merrill, Gentilly	6	"	.75
July	29	Edw. Lanetot, Gentilly	10	"	1.25
July	29	John Demarais, Gentilly	3	"	.38
July	29	Patrick Kelly, Gentilly	25	"	3.13
July	29	Rock Valley, Gentilly	14	"	1.75
July	29	J. B. Gufault, Gentilly	20	"	2.50
July	29	Dan'l Sully, Gentilly	10	"	1.25
July	29	Gilbert Brault, Gentilly	8	"	1.00
July	29	Pierre Dufault, Gentilly	9	"	1.13
July	29	Geo. Plant, Gentilly	3	"	.38
July	19	O. O. Reed, Rothsay	20	"	3.00
July	19	Lewis Heggan, Rothsay	5	"	.75
July	30	Gilbert Braatelin, Rothsay	15	"	2.25
July	30	Hans Christianson, Rothsay	43	"	6.45
July	30	O. P. Weston, Rothsay	18	"	2.70
July	30	Anton Foss, Rothsay	4	"	.60
Aug.	3	Ed. Steiner, Rothsay	15	"	1.95
Aug.	3	John Longfelt, Rothsay	25	"	3.25
Aug.	3	John Rolin, Rothsay	25	"	3.25
Aug.	4	H. Knudson, Everdell	25	"	3.25
Aug.	12	H. J. Marsh, Everdell	25	"	3.25
Aug.	13	A. Sitar, Breckenridge	25	"	3.75
Aug.	14	August Danielson, Rothsay	5	"	.65
Aug.	15	Hugo Koppe, Rothsay	15	"	1.95
Aug.	17	Benesh & Pierce, Breckenridge	50	"	7.00
Aug.	18	Benesh & Pierce, Breckenridge	50	"	7.00
			894½	"	$122.74

Fig. 9. Hopperdozer at work. Original.

e grasshoppers causing the damage in 1910 have been, as far have seen, the Red-legged Locust or grasshopper, the Lesser ory Locust or grasshopper, the Two-striped Locust or grass- ; the latter being extremely numerous, compared with its

Fig. 10. Hopperdozer at work, front view. Original.

numbers in former years. Some farmers thought, because they saw swarms of locusts in the air, that they must have been the Rocky Mountain form; but we saw no evidence of this species, and will have to call attention to the fact that the Lesser Migratory Locust, as well as other forms, probably, have this habit in common with the Rocky Mountain variety. Further, farmers must bear in mind that any grasshoppers can be destructive in proportion to their abundance. They do not need to come from the Rocky Mountains in order to be dangerous. Friends of the writer, entomologists who work in Colorado and Montana, stated in 1909 and also in 1910, that for some time they had been unable to find, in their representative states a trace of the form known as *The Rocky Mountain Locust, Caloptenus spretus;* which species, by the way, is very closely allied to our common and destructive Lesser Migratory Locust. While in the field in Wilkin County, July 6th and 7th 1910, we found the Two-striped Locust very abundant, for the most part full-grown and some mating. Of the Red-legged and Lesser Migratory there were more young than adults. At these dates also we occasionally saw quite large swarms high in the air, and coming apparently from the West.

Observations.

In addition to field work with the farms in 1910, we have made some laboratory observations which may be of interest, and tried experimentally a solution (arsenite of soda) in successful use in South Africa.

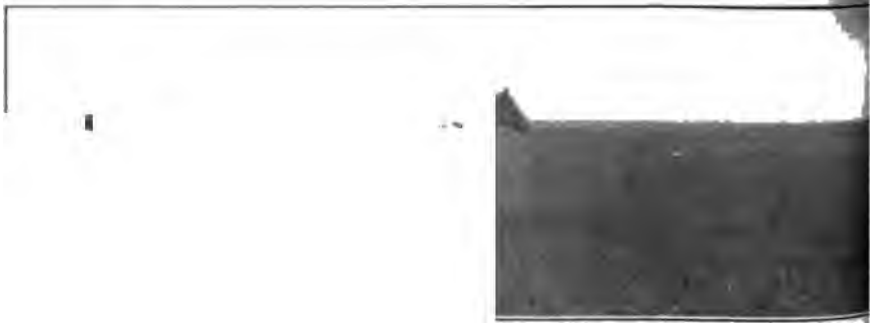

Fig. 11. Another view of working hopperdozer. Original.

1. We have found that young hoppers, freshly hatched, can live from four to five days without food under trying conditions—a fact which is not particularly encouraging to the farmers.

. A very young hopper will average, in traveling on hard soil, t one foot every five minutes. They make about one foot at mp, rest awhile and jump again. On soft soil their rate of l is very much less than on hard—only a very few inches every minutes.

Fig. 12. Scooping out the dead hoppers. Original.

. The accompanying drawings, made from living specimens iss Iris Wood, show the successive stages in the hatching of a hopper, and its freeing itself from the enveloping membrane, -called "amnion." Fig. 1, breaking through the egg-shell; 2, a few minutes later; Fig. 3, still later; Fig. 4, freed from gg-shell, but still wrapped in the "amnion"; Fig. 5, kicking he "amnion." The length of time required in this process d from about four minutes to fifteen, possibly dependent upon mount of moisture present in the soil containing the eggs.

Quoting from Miss Wood's notes, figure 3 was drawn at a time when "a strong movement was observed between thorax and abdomen." Almost no independent movement of legs until the pellicle or "amnion" is cast off. This (casting off of the amnion) began to take place immediately when the hopper was free of the egg-shell (Fig. 4). The pellicle split across the back of the thorax, and, by movements more of the body than the appendages, was passed forward over the head. The antennae and mouth parts were drawn out of the pellicle; then the first and second pair of legs were drawn out, and in about three minutes the entire amnion (pellicle) was cast off, but clung several minutes to the posterior end of the abdomen. As soon as the hind legs were free, the hopper turned over and began to walk, at first using only the two front pairs of legs, the tibiae and femora of the hind legs being close together and raised, and the body dragged along by the front pair."

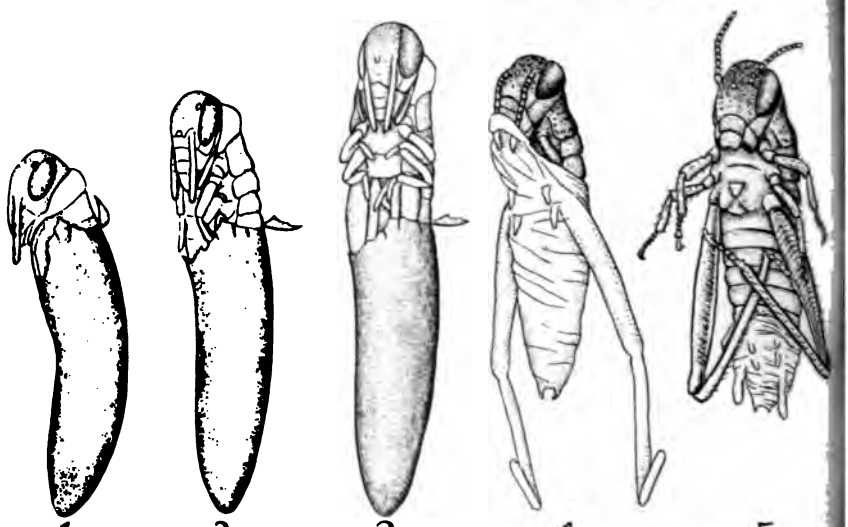

Fig. 13 Five stages in the hatching of a grasshopper. Original.

Remedies and Preventive Measures.

(1) THE PLOW AND THE HARROW are the most important enemies of grasshoppers. A faithful use of the plow on the part of all farmers in a neighborhood, and all land-owners, will materially reduce the number of this pest in any given locality. As is well known, grasshoppers lay their eggs in late summer and early fall, in pockets made by the female, an inch or an inch and a half deep. These

eggs hatch in the spring, in normal years between May 1st and May 15th, or thereabouts. These pockets are turned over by the plow, preventing the escape of most of the newly-hatched hoppers. Consequently late fall or early spring plowing (five or six inches deep) is one of our best remedies against these insects. Evidently, there must be co-operation on the part of all farmers in a neighborhood, in this important matter. Where deep plowing is impossible, a faithful harrowing would help shallow plowing, thus more effectively breaking up the egg-masses and exposing the eggs to the varying changes of the weather. The plowing of roadsides in the late fall or early spring, where there is serious infestation, is desirable.

(2) PLOWING UNDER YOUNG HOPPERS: Young hoppers just hatching can sometimes be taken care of by plowing them under, beginning on the outside of the field in which they are hatching, and plowing toward the center. This turns many under, and by depriving them of almost all food, makes it much more difficult for them to reach the edge of the plowed piece where they might damage a valuable crop.

(3) CRIDDLE MIXTURE: When grasshoppers are young, or half grown, a poisonous bait, known as the Criddle Mixture, has proved effective in many parts of the country. This consists of one part Paris green and about 100 parts of fresh horse-manure, by measure. Enough water is added to make the mass soft without being sloppy. It can be taken to the field on a wagon or stone-boat, and scattered about by means of a paddle. One might think that turkeys and other fowls, in picking over such material for bits of undigested grain, might be poisoned. This, in our own experience, does not seem to be the case. It would probably be dangerous if used in proximity to small chickens.

(4) BURNING YOUNG HOPPERS: It is sometimes possible to burn over a tract swarming with young hoppers, and thereby save an adjoining crop. This burning, however, must be done with care, and the farmer must decide whether he is doing more harm to his own crop than he is getting benefit thereby.

(5) POISONED BRAN: Garden truck to which chickens do not have access may be protected to some extent by mixing bran with water to the consistency of chicken feed, adding Paris green until the mixture has a greenish color (2 parts Paris green to 25 parts bran, by measure), sweetening with cheap syrup or molasses, and

strewing the same amongst the plants, taking care not to place it directly against a plant. Spraying garden vegetables and other plants with arsenate of lead, 4 pounds to 100 gallons of water, would also serve to protect them.

(6) HOPPERDOZERS: These, though not giving complete satisfaction, are regarded as one of the best helps; in fact, almost the only help, for a farmer upon whose crops the grasshoppers are pouring from adjacent unplowed fields. Hopperdozers are made of sheet iron, generally 16 feet long (though they may be shorter) and the drawing which accompanies this article illustrates a general

Fig. 14. Experimenting on small scale with arsenite of soda. Original

plan. The upright part behind may be canvas or cloth, or of sheet iron. With the details suggested by Fig. 8 farmers should be able to construct one to suit their needs, and possibly improve upon the plans given. I might say, in this connection, that a horse at each end is better than one horse in the middle. When wanted for use, a little water is placed in the pan and also thrown against the canvas-cover back, if canvas is used. This back is then drenched with kerosene, and about two quarts of the oil are poured on the water in the pan. The machine is driven back and forth over field of young grain or flax which is being eaten, and bushels of the insects are killed in this way. This work is best done when the day is bright and warm, and before the insects reach full size. Even though a grasshopper may jump out of the pan,—if he has been in *the kerosene, he is* doomed.

(7) PLOWING A STRIP TO CHECK ADVANCES OF YOUNG HOPPERS: In case a farmer is located next to an immense tract of unplowed land, whereon grasshoppers are hatching in large numbers and threatening to overrun his crops, manifestly he cannot do the impossible—in other words, plow all the reverted or unused land;—but he might plow a strip of this infested land several rods wide, along the side of his own land, thereby forming a barrier which it would be difficult for the very young hopper to cross, and thus giving time to prepare other means, (hopperdozers, for instance) to use against them.

(8) THE MINNESOTA GRASSHOPPER LAW: This is strikingly ineffective, as stated above, and we would do well to follow the example of North Dakota in this respect. The method of procedure under the Minnesota law is as follows:

Complaint of the infested land should be made in the fall, to the State Entomologist, or to the Board of County Commissioners, or both, accompanied by specimens of eggs. The entomologist examines the land; and, if conditions justify it, he recommends to the Board of County Commissioners that the land be plowed. The County Board serves notice on the owner or lessee of infested land, requesting him to plow within a certain time. If he fails to do this, the county plows the land; and, if said plowing benefits him in raising crops immediately after, assesses him to refund the money paid. It is evident that, under the provisions of this law, the county will have to pay most of the bills for plowing. If our farmers think this law should be made more stringent, and the owner of said property be made to pay for the plowing in any event, it is in their power to make an effort to amend the present law to that end.

The North Dakota law, given below, is more stringent in that the expense of plowing is made a lien upon the land, and the record owner or incumbrancer of said land must pay the cost of plowing.

Revised Code of North Dakota, 1905.

ARTICLE 27.—DESTRUCTION OF GRASSHOPPERS.

Sec. 2108. ***Duty of County Commissioners.***—**The Board of County Commissioners shall have power, and it shall be their duty, to order the plowing of land, and such other means as they deem expedient, wherever and whenever they deem it necessary to cause the destruction of grasshoppers and Rocky Mountain locust's eggs: and said plowing and other means shall be done at the time and in the manner directed by said Board of County Commissioners by the owner or incumbrancer, if any, of said land immediately after receiving notice thereof from said Board of County Commissioners.**

Sec. 2109. *Notice, how and when served.*—Where the owner of the land on which said Board shall have decided plowing must be done for the purposes herein specified, cannot with reasonable diligence be served with notice within the state, it shall be sufficient to serve the said notice by publication thereof for two successive issues in the official newspaper nearest said tract.

Sec. 2110. *Must plow in five days.*—If the owner or incumbrancer, if any, shall fail to plow said tract or tracts as ordered and directed by said Board of County Commissioners, within five days after notice as herein provided, then, in that event, said Board of County Commissioners shall cause said tract or tracts to be plowed, or so much thereof as may be by them deemed necessary, and audit and pay for said work out of the general fund of said County, upon warrant as in other cases made and provided.

Sec. 2111. *Expense a lien upon land.*—Immediately after the said accounts are audited and paid by said County Commissioners, it shall be the duty of the County Auditor to certify to the County Treasurer the amount so expended upon each piece and parcel of land, which certificate shall contain the name of the record owner or incumbrancer of said tract, a true description of said land, the amount paid by the county for plowing done thereon; and the County Treasurer shall thereupon enter said amount against said land as taxes are entered against said land, and the said amount shall constitute a lien upon said land prior to all other incumbrances, and shall bear interest at the rate of seven per cent per annum from date of entry by the County Treasurer, and collection thereof may thereafter be made and enforced in the same manner as delinquent taxes are enforced and collected against real property.

Sec. 2112. *Payment out of general fund.*—When the Board of County Commissioners shall deem the plowing of state land necessary for the purposes herein specified, they shall order the same done, and payment therefor may be made out of the general fund of the county, upon warrant as in other cases provided; provided, however, that no growing crops shall be destroyed under the provisions of this article; provided, further, that when the Board of County Commissioners shall deem it necessary to cause plowing upon government land held by resident claimants, or other means to cause the destruction of grasshoppers and Rocky Mountain locusts, said claimant shall be liable to the county in a civil action for all moneys necessarily expended in carrying out the directions of the Board of County Commissioners for the purpose herein specified.

A Partial List of Reverted Lands in Wilkin County in 1910.

Of all localities this county appeared to be the worst affected during 1910, and since we have found that similar conditions in other counties in the Red River Valley are largely responsible for grasshopper injury, we give here a partial list of these lands in Wilkin, with the names of the owners or representatives of the owners, as reported to us at the County Auditor's office:

ANDREA TOWNSHIP.

Sec. 5, W½ and SE¼.....Mary A. Kenefic, care G. I. Byget, Dayton, Ia.
Sec. 6, SW¼ .....O. Bertleson et al, Fergus Falls.
Sec. 11, NW¼ .....J. R. Milliken, N. W. Nat'l Bk., Sioux City, Ia.
Sec. 8, SW¼ .....Camelia Allen.
Sec. 9, NW¼ .....M. R. Keeley, Dwight, Ill.
Sec. 17, NE¼ .....P. G. Shaw, Pocahontas, Ia.
Sec. 18, SW¼ .....A. W. and Willie Anderson, Stanhope, Iowa.
Sec. 19, NW¼ .....Paul Rinnengen, Big Bend Land Co., Spokane, Wash.
Sec. 20, NW¼ .....Howard Espeset, Estherville, Ia.
Sec. 22, NE¼ .....Jacob Niebles, Fergus Falls.
Sec. 22, SE¼ .....F. F. Schnetstay, Fergus Falls.
Sec. 26, SW¼ .....H. G. Richter, Foxhome, Minn.
Sec. 27, NE¼ .....E. and L. Edwards, Alta, Ia.
Sec. 28, NW¼ .....G. W. Johnson, Schaller, Ia.
Sec. 28, SW¼ .....A. R. Kitts, Fergus Falls.
Sec. 28, SE¼ .....S. A. Rouse, Mankato.
Sec. 29, All .....James Espeset, Estherville, Ia.
Sec. 30, E½, 220 acres.....A. R. Kitts, Fergus Falls.
Sec. 36, N½ .....W. L. Austin, Rutland, Ill.
Sec. 36, SW¼ .....F. F. Frost, Des Moines, Ia.
Sec. 36, SE¼ .....C. F. Livermore, Fairmont, Minn.

AKRON TOWNSHIP.

Sec. 25, NE¼ of NW¼.....Sec. 20, Jonas Swenson, Fergus Falls.
Sec. 25, W½ of NW¼.....Sec. 20, Jonas Swenson, Fergus Falls.
Sec. 25, NE¼ .....Caspar Lien, Fergus Falls.
Sec. 25, SE¼ of NW¼.....A. Swenson, Rothsay.
Sec. 25, N½ and SW of SW.....A. Swenson, Rothsay.
Sec. 25, SE¼ of SW¼.....Frank Gronnos, Elizabeth.
Sec. 25, SE¼ .....Andrew Christofferson, Rothsay.
Sec. 30, SE¼ .....O. G. Felland, Rothsay.
Sec. 30, NW¼ .....H. G. Heikland, Spencer, Ia.
Sec. 32, SW¼ .....M. J. Adams, Ames, Ia.
Sec. 33, SW¼ .....H. J. Olson, Rothsay.
Sec. 8, E½ of NE¼ .....E. E. Secor, care Harvey Johnson, Banning, Calif.
Sec. 8, W½ of NE¼.....H. L. Shirley, Breckenridge.
Sec. 8, SE¼ .....H. L. Shirley, Breckenridge.

TANBURG TOWNSHIP.

Sec. 29, W½ ..... H. K. Farries, Morning Sun, Ia.
Sec. 30, E½ of SW¼ ..... J. E. Vincent, Britt, Ia.
Sec. 30, E½ of NW¼ ..... C. P. Bailey.
Sec. 30, W½ of NE¼ ..... B. F. Parker, St. Paul.
Sec. 35, NE¼ ..... O. E. Jonsrud, Rothsay.
Sec. 35, SE¼ ..... O. A. Smekop, Rothsay.

MEADOWS TOWNSHIP.

Sec. 24, SE¼ ..... Walter Davis, care F. E. Boone, Breckenridge.
Sec. 24, W½ ..... J. A. Wigdahl, Rothsay.
Sec. 14, NE¼ ..... W. R. Appleton.
Sec. 14, NW¼ ..... O. P. Burrows, Breckenridge.
Sec. 14, SW¼ ..... F. C. Felts, Fort Dodge, Ia.
Sec. 14, SE¼ ..... F. C. Felts, Fort Dodge, Ia.
Sec. 11, N½ of NW¼ ..... P. L. Christianson.
Sec. 11, N½ of NE¼ ..... P. L. Christianson.
Sec. 11, S½ of NE¼ ..... C. S. Marden, Barnesville, Minn.
Sec. 11, S½ of NW¼ ..... C. S. Marden, Barnesville, Minn.
Sec. 11, SW¼ ..... C. S. Marden, Barnesville, Minn.
Sec. 11, SE¼ ..... J. F. Buggy, Buffalo Centre, Ia.
Sec. 10, E½ ..... G. E. Ward, care J. C. Kain, Breckenridge.
Sec. 9, SW¼ ..... R. F. Locke, Rockford, Ill.
Sec. 9, SE¼ ..... Oscar Anderson.
Sec. 21, E½ ..... Otto Berg.
Sec. 26, NW¼ ..... S. I. Dakin, Breckenridge.
Sec. 20, W½ ..... E. J. Elliot, care E. G. Everett, Des Moines, Ia.
Sec. 30, SE¼ ..... F. T. Berkey, Breckenridge.
Sec. 12, NW¼ ..... G. W. Barrows, Breckenridge.
Sec. 23, N½ ..... David Meridith, care J. A. Carlton, Dubuque, Ia.
Sec. 2, NE¼ ..... H. K. Bjargaard, Rothsay, Minn.

Testimony as to Conditions.

The following letter, taken from a large number of similar communications, received in 1910, is fairly indicative of conditions in the Western and Northwestern part of our state.

"Everdell, Minn., June 25, 1910

Mr. F. L. Washburn,
State Entomologist,
St. Anthony Park, St. Paul, Minn.

Dear Sir: Received your order dated June 18th, for 25 gallons of kerosene, and wish to thank you for the same. At the same time I want to call your attention to the fact that the farms I am working have a total of about twelve hundred acres in crop this year, and very likely there will be considerable more needed than the 25 gallons. Will you not furnish more?

The grasshoppers seem to be very numerous, and already it is claimed that they have done and are doing damage. A number of farmers are trying to work against them with the hopperdozers, but the trouble is that there is so much land not being cultivated, growing grass; and it seems that they are very numerous on such land, and the trouble is that they breed on such land and afterwards go to the grain on the cultivated land.

The situation here is fierce. This will be the third successive year that the grasshoppers have been doing damage on a large scale, and if there is anything that you can do through the state to help the farmers in this locality, it ought to be done.

Thanking you in advance for a prompt reply, I am,

Respectfully yours,"

These Grasshoppers Are Not the Rocky Mountain Locust or Grasshopper.

Reference has been made above to the fact that the grasshoppers doing the damage in 1909 and 1910 are not the Rocky Mountain variety; and it was further stated that for some reason the latter form (*M. spretus*) has not been apparent in its usual haunts for many years. In this connection I quote from two letters recently received. One from the State Entomologist of Montana reads as follows:

"I have been collecting Orthoptera in Montana for thirteen seasons now, and have in the collections about 170 species, of which about a dozen are new and undescribed. I have looked particularly for *M. spretus* (Rocky Mountain Locust), but have not taken a single specimen, nor have I taken one that approached this species. This has been particularly interesting to me, in

view of the fact that parts of Montana were formerly considered to be within the so-called permanent breeding grounds. I have collected within this tract as well as outside of it."

The other is from a prominent Colorado entomologist:

"* * * In all of our collecting here during the past twenty years, and it has been quite extensive, we have never taken an example of the Rocky Mountain Locust, *M. spretus*. It is quite a disappointment to me, as I supposed I should certainly have an opportunity to collect this insect many times in Colorado, as Riley had given the permanent breeding-grounds of this insect as extending over a considerable portion of the mountains and foothills and even the plains in this state."

The Lesser Migratory Locust, *M. atlanis*,—one we have with us all the time, capable, as we have seen, of doing great injury when occurring in large numbers, and with somewhat the same habits as the Rocky Mountain form,—is so closely akin to the latter that some entomologists regard them as almost identical, the latter possibly a long-winged variety of the former. The casual observer, noting them in the field, certainly could not distinguish the one from the other.

Mr. Urbahns was sent into the field twice during the summer. His report follows:

First trip made to Foxhome, Minn., June 3rd: Drove out to farms of Chas. Reber, O. L. Fuder, Geo. Sutter and G. W. Greiner. The young hoppers, just hatching, were very abundant, especially so on high sandy waste lands. Burning of meadows and idle lands was practiced wherever possible. In some cases this was done too early to destroy a large percentage of the young hoppers, and in other cases meadows were burned so late as to destroy the grass crop.

A movement was organized to clear the fields of grasshoppers by the use of hopperdozers, through the joint efforts of the farmers of the entire locality. Mr. Chas. Reber was appointed chief in the movement. Promises for the construction and immediate use of eight hopperdozers were secured.

Second trip to Foxhome, in June: Arrangements were made over telephone by which several farmers from south of town were met at the hotel. Two groups of farmers were met in the country at five and eight miles northwest of town. Fields were visited where hopperdozers were in use. The discussions carried on led to several changes in the construction of hopperdozers. Grasshoppers were apparently on the increase, but reports of the work were quite favorable and encouraging. A good number of hopperdozers were in use, and farmers were urged to make greater use of the same.

Rothsay, Minn.: Met four farmers at the home of Ed. Steiner, eight *miles southwest*, and then drove two miles north to meet eight farmers, who

had gathered at a cross-road to discuss the grasshopper situation. Upon driving one mile farther north, to the home of M. F. Fisher, a meeting was held in the yard, with six farmers present. These meetings were all hurriedly arranged by telephone, through the help of farmers interested in combating insect pests. Farmers were reporting much idle land as a public nuisance, and nearly ten thousand acres were listed. Over eight thousand acres of such land were listed in a single township.

Gentilly, Minn., June: Drove out eight miles to Gentilly from Crookston, and met a group of farmers by appointment. Twelve men interested in combating grasshoppers were present. A few others took slight interest. Reports of abundance of grasshoppers came in from all sides of town, and mostly from fields which were high and sandy.

The situation was discussed, and the most practical methods of control were considered. Grasshoppers in this section were further advanced than they were around Foxhome or Rothsay. Farmers were enthusiastic, and seemed willing to at once take up the work as outlined.

Beltrami, Minn.: I was called to this place by Mr. Johansen. The grasshoppers had destroyed the barley in spots on a field of Mr. C. K. Luhman. A few crude hopperdozers were in use. A gathering of farmers was held on Mr Luhman's farm, and the work was discussed. Young flax-fields were suffering severely, and the flax was too small to allow of the practical use of hopperdozers. Grasshoppers were mostly about half-grown.

A second meeting was held in the evening, at the home of Ole Olson, with seven farmers present, for the purpose of discussing the construction of a most efficient hopperdozer.

WORK OF 1909 WITH THE APPLE LEAF HOPPER.

Empoasca mali.

This practically marks the completion of work upon this insect, done under the provisions of the Adams' Act, though some points of interest in its life-history yet remain, inviting further endeavor. The work of 1908 on this species was described in the Twelfth Report of the Minnesota State Entomologist. Summarizing that work we cite the following observations:

1. **Fall-laid eggs were not found on any herbaceous plant.**
2. **The insect winters only in the egg stage.**
3. **Oviposition in summer was found to occur on the petiole of apple and clover, and probably occurs on other herbaceous plants.**
4. **List of food-plants was given.**
5. **Five nymphal stages were reported, covering a period of about twenty-two days.**
6. **Adults may live fourteen days or over (1907 experiments indicate that they may live thirty days or more).**
7. **The location and appearance of the winter egg-blister and the contained egg.**
8. **Remedial measures.**

The work of 1909 practically corroborates that of 1908, and adds certain new facts. We add these conclusions and the chief items of work:

9. **This species deposits its winter eggs only on perennials, and of perennials, as far as can be determined, only on the apple.**
10. **There are certainly three, and probably four broods in Minnesota.**
11. **Manner of emergence of nymphs from egg-blister.**
12. **Further observations on life-history.**
13. **Remedial measures.**

The work in 1909, as in 1908, was in charge of Dr. H. J. *Franklin, and his* report in detail is as follows:

Empoasca mali.

Alfalfa and dahlia plants, which had been badly infested with *Empoasca mali* during the summer and fall of 1908, were brought in and placed in the insectary, and kept in the cold part of the greenhouse through the winter. These plants showed the effect of the insect's attack plainly when brought in, and there were many of the insects still on them at that time—October 8th. No specimens of *Empoasca mali* lived through the winter on these plants, and no nymphs emerged from the tissues the next spring (spring 1909). *This goes to show that E. mali does not deposit winter eggs in the tissues of herbaceous plants, and that the species relies entirely upon the eggs deposited in the blisters found on the bark of perennials.* These plants were last examined in the season of 1909 on June 5th, and the plants were at this time more or less dead and dry, except for the new growth which had started up during the month of May, 1909.

Fig. 15. Emergence of nymphs from egg blister. Original.

Apple branches were examined in the orchard early in the spring and were brought in from time to time, and the egg blisters of *E. mali* carefully examined, to find out when the nymphs should begin emerging from the blisters. Nymphs were found in process of emerging on May 24th, the apple leaves at this date being not over one-third developed. Numerous hoppers were found at this date in first and second instars on the apple leaves, and it seemed probable that some of them hatched from the eggs as early as May 21st. Several adults were reared from nymphs hatched from these blisters, and, with one exception, they all proved to be *E. mali.* One undetermined specimen, which was slightly smaller than *E. mali,* was reared from a nymph which emerged from an egg-

blister found on apple, which could not be distinguished in any way from the true egg-blister of *E. mali*. On May 26th Miss Wood made several drawings to illustrate the method of emergence of the *E. mali* nymphs from their egg-blisters. These nymphs emerged through the oviposition opening of the blister, making this opening somewhat larger during the process. When a young hopper begins to emerge from its egg-blister, if the weather is fairly warm, it will often complete the process in a few minutes. One was timed from the moment the vertex of its head appeared until it got clear out of the blister, and it took five minutes. Another was watched from the time it was half-way out until it got entirely free from the blister, and it took about thirteen minutes. The young hoppers were observed to be still emerging from their egg-blisters, in large numbers, on May 26th. The flower-buds of the apple trees were at this time, as a rule, just on the point of bursting into bloom, many of them being already in bloom, and the leaves were from one-third to two-thirds developed. From these observations there is now no doubt that the egg-blisters, which were so carefully measured by Franklin last fall, on the branches of the trees in the orchard, were those of *E. mali*.

Evidence that E. mali does not hibernate in the egg stage on other perennials than the apple.

Young leaf-hoppers were gathered from the foliage of elm, white oak, red oak, gooseberry, black birch, linden and white birch, from June 4th to June 10th (at which time the nymphs of the first brood of *E. mali* were developing to the adult condition in the apple orchard) and reared to adults, to see if any *E. mali* had hatched from the winter egg in any numbers on these trees. Adults were reared from nymphs found on all these food-plants, but not one of them proved to be *E. mali*. Currant bushes, box elders, mountain ash, dogwood and some other perennials of less importance were carefully examined for young leaf-hoppers from time to time during the first two weeks in June, and not a single nymph or adult of any species was found. Willows were examined carefully on June 11th, and only a single young leaf-hopper was found. This was reared, and proved to be *E. mali*. Plum trees were also examined carefully on June 7th, and only two nymphs of leaf-hoppers were found. One of these was reared, and proved to be *E. mali*. These observations clearly indicate that *E. mali* seldom, if ever, form winter egg-blisters on any of the kinds of trees examined, namely, elm, white oak, red oak, gooseberry, black birch,

white birch, linden, currant, box elder, mountain ash, willow, dogwood and plum. Even in the case of the two last we have no certain proof that the specimens of *E. mali* reared from them did not first hatch from eggs in blisters on apple trees, and then get blown from the apple to the plum and willow trees, which were about fifty yards distant, though the chances for this, considering the observations made by sweeping on alfalfa, do not seem great.

Notes and Observations on Life-History.

On June 4th trees of the orchard on the flat were examined for this species; no adults were found on the apple trees, though nymphs were present in all stages. The alfalfa field just across the road was examined, to the north of this orchard, and swept with a fine collecting-net, and adults of *E. mali* were found. No nymphs in any stage were found upon the alfalfa at this time, which again shows that this species does not pass the winter in the egg stage on or in alfalfa. The adults found on the alfalfa at this time had evidently come to maturity on the apple trees in the neighboring orchard, and then either flown or been blown by the wind from these trees on to the alfalfa. Counts were made of the number of specimens of adults that were taken by sweeping across the alfalfa field at various distances from the orchard. The field was 164 paces long, extending directly away from the orchard, and the width being about the same (52 paces) from end to end. For each count the width of the field was swept, taking one good sweep of the net at every step. The following table gives the number of sweepings, their distance from the orchard, and the number of *Empoasca* captured.

Paces from Orchard	Number of specimens taken	Sweepings.
9	5	Once across.
130	1	Once across.
13	5	Once across.
21	3	Once across.
40	6	Once across.
60	8	Once across.
80	3	Once across.
100	4	Twice across.
120	3	Once across.
140	2	Once across.
164	3	Twice across.

Making a total of thirteen sweepings across the field, and of 43 adults collected in all.

It will be noticed by this table that there was a slight falling off in the number of specimens toward the further end of the field; but that, aside from this, the *Empoasca* adults were pretty evenly distributed over the entire field. This field of alfalfa was swept several times after this, in a similar manner, with the results given below. On June 9th:

Paces from orchard.	Specimens of adults taken.
10	14
20	7
40	10
60	13
80	7
100	2
140	15
120	11
160	12

Making a total of nine sweepings in all, and 91 specimens taken. No nymphs at all were found in any of these sweepings. It will be again noted that quite as many specimens were taken at a distance from the orchard as close to it.

On June 11th the field was swept again with following results:

Paces from the orchard.	Number of individuals found.
10	37
20	22
40	19
60	12
80	14
100	12
120	21
140	18
160	13
164	24

Making a total of ten sweepings and 192 specimens.

On June 14th the results of the sweepings were as follows:

No. of paces from orchard.	No. of specimens taken.
10	19
20	23
40	22
60	14

80	14
100	7
120	13
140	14
160	15
165	36

Making a total of ten sweepings and 177 specimens taken.

On June 21st results of the sweepings were as follows:

No. of paces from orchard.	No. of specimens captured.
9	24 adults, 1 young.
13	30 "
20	30 "
40	28 "
60	18 "
80	28 "
100	24 "
120	20 "
140	22 "
160	23 "
165	21 "

Making a total of eleven sweepings and 268 specimens. It should be noted that this is the date on which the first nymph was found in the alfalfa. It was very small, being in the first stage. As the field of alfalfa on which we had made the previous sweepings had been cut down, we had to sweep another somewhat smaller field. The sweeping and counting on this field was done in the same way as in the other field, and the results were as follows, the field being about the same width as the one above, June 25th:

First sweeping across the field	55 specimens.
Second sweeping	60 "
Third sweeping	66 "
Fourth sweeping	40 "
Fifth sweeping	54 "

Making a total of five sweepings and 275 specimens. This field was somewhat farther away from any apple trees than was the first one. A few nymphs in the first stage were found. If the results of the sweepings made on these different dates be examined and compared carefully, it will be seen that the individuals taken increased steadily in numbers from the first to the last, with the exception that the sweeping on the 14th of June gave a somewhat smaller number of adults than did that on the 11th. This falling off on the 14th of June, however, is readily accounted for by the

fact that on the 12th, and again on the 13th, there was a considerable amount of rainfall—over half an inch of water falling on the 13th—it being very probable that so much precipitation would kill off the adults in considerable numbers.

On July 9th the alfalfa field which was cut on June 24th was swept, and a number of specimens of *E. mali* were found; the alfalfa since it was cut having attained a considerable new growth.

Sweepings had been made upon clover at about this date (July 9th), and nymphs were found in large numbers. Nearly as many adults were found upon the alfalfa on this date as were found on the clover, in proportion to the number of sweeps of the net. No nymphs, however, were found. The adults had apparently but recently either flown or been blown on to the alfalfa, from the neighboring orchard and from surrounding fields. The absence of nymphs on this field, which had been cut, goes to show that if legumes such as clover and alfalfa be cut just before the eggs for the second brood hatch, much of the infestation for the second brood may be reduced.

On July 24th fields of wheat, rye, oats, barley and flax were examined and hardly any *E. mali* were found in them. On August 24th a large patch of raspberries, at Mr. J. F. Larson's place at Stillwater, was looked over and many of the leaves on the raspberry canes were found to be badly curled as the result of the work of *E. mali*. Many canes had all the leaves curled up, and the adults flew off from these in large numbers when the canes were shaken. On August 26th a large number of apple branches in the flat orchard were very carefully examined, and we could not find any egg-blisters of *E. mali*. On September 13th, however, another examination on some of the trees close to the alfalfa disclosed the egg-blisters of *E. mali* present in considerable numbers. It seems probable that oviposition had begun several days before this date. The blisters were not, at this time, nearly so numerous as they were last fall after oviposition had ceased; this showing that adults were still laying at this date (Sept. 13th).

On September 17th the clover fields and alfalfa fields were swept, and it was found that *E. mali* were far less numerous than they had been before this date.

In connection with the work on *Empoasca*, the accompanying chart, constructed by Mr. Stafford, shows the relative abundance of adults and nymphs, indicated by his sweepings of clover upon thirteen dates. This is numerically expressed as follows:

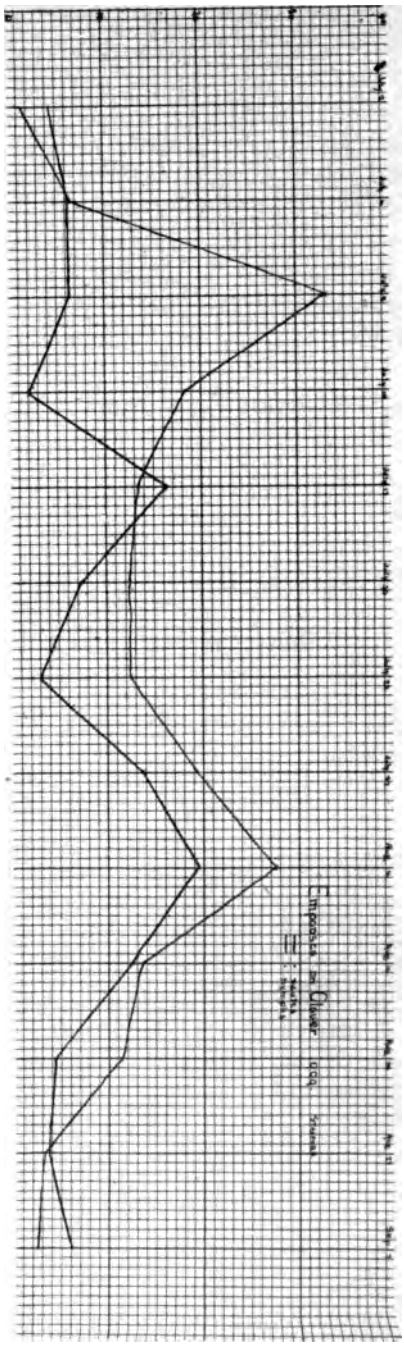

Fig. 16. Chart showing comparative abundance of adult leaf hoppers and nymphs at different dates. Upper line, nymphs; lower, adults. Stafford.

Date—	Adults	Young
July 2	4.3	1.3
July 6	6.2	6.8
July 8	6.4	33.0
July 10	2.0	18.2
July 17	16.2	13.4
July 20	7.5	12.5
July 22	3.0	12.5
July 27	13.8	19.6
Aug. 4	19.2	27.7
Aug. 14	12.6	13.6
Aug. 24	4.4	11.6
Aug. 27	3.8	3.2
Sept. 7	6.0	2.4

Length of Life of the Adult.

Experiments were made to find out how long the adul
E. mali live, by taking reared specimens and keeping them on
twigs in the insectary. We were unable to get any adult to
longer than nine days; but our results, we fear, were deceptiv
conditions in the experiments could not be made exactly nat
and it is probable that the adults of *E. mali* really live conside
longer than this in nature. Experiments along this line in
indicate that they may live for thirty days or more.

Number of Broods.

The first brood began emerging in the insectary about May
They may have begun to emerge even earlier than this, in
numbers, out of doors, as is shown by the sweepings on al
The earliest individuals of this brood had become adult in co
erable numbers by June 4th. The first young of the second b
collected on alfalfa, was found on June 21st. As no swee
was done on the alfalfa between the 14th and 21st, it is
possible that the first young really hatched several days befor
21st; though it is certain that, if they did do this, it was in
small numbers. Nymphs of this second brood were collecte
July 9th, and the first adults were reared from them on July
It is almost certain that the earliest of this second brood rea
the adult condition several days earlier than this. If we
June 21st (the date on which the first nymphs of this brood
collected on the alfalfa) as the date of earliest appearance o
nymphs of this brood, and add twenty-two days (the ave
number of days passed in the nymphal stages, according to
1907 and 1908 experiments and observations) to this date

ave July 13th as the date on which the earliest of the second rood become adults. Adults of this second brood were reared id placed in pot lamp-chimney experiments, in order to get them to y eggs for the third brood. They were placed on apple and box ler seedlings. These box elder seedlings had been gathered in ay and kept in the insectary, and so had a good chance of not ving had *Empoasca* eggs deposited in their tissues previous to the ening of these experiments. These adults were allowed to nain in each experiment for two days, and were then removed. this way it was possible to figure out approximate length of time ent in the egg stage at the time of the season during which these periments were conducted. The first of these experiments was ened on July 13th, and the first young which appeared in that ty was found on July 31st. These experiments were continued til August 25th, and fully twenty nymphs of the third generation re hatched. The length of time spent in the egg stage by these mphs ranged from about seven to about thirteen days, the aver- e being about nine and one-half days. Adding twenty-two days he average length of time spent in the nymphal stage) to July st, the time of the appearance of the first young of the third neration in these experiments, we get August 22d as the date which the first of the third generation became adults. It seems ely (see above), judging from the probable time at which the st of the second brood became adults, that in reality the earliest of e third brood became adults several days earlier than August 22d, obably as early as August 18th at the latest. As winter egg- isters are not found until into September, it seems fair to assume at these earliest adults of the third brood do not deposit winter gs, but lay eggs for a fourth summer generation instead. The rther fact that living nymphs were found in all stages, on alfalfa, to nearly the first of November, in the season of 1908, would so seem to indicate that there is at least a partial fourth brood of . *mali* in Minnesota each year, though it must be remembered, of urse, that development is much slower in the cool weather of eptember and October than during the summer months.

Summarizing, we may say that there are certainly three, and ossibly four, broods of *E. mali* per season in Minnesota.

Economic Experiments.

Experiments with the hopperdozer for Empoasca on apple nursery stock:

A hopperdozer was constructed according to the plans given in the drawings which accompany this report, and was covered with canvas; the canvas being painted on the inside, in one trial, with crude oil, and in the other with tree tangle-foot; the idea being to drag the hopperdozer along the rows of small trees, the trees

Fig. 17. Hopperdozer for use on nursery rows. **Franklin.**

g through the hopperdozer and striking against a bumper at its middle, and the adults of *E. mali* being shaken off from :es, and flying in all directions, and naturally a great many m lighting on the sticky oil or tanglefoot, and thus being and destroyed.

e experiments with the hopperdozer were carried out in the y of Mr. Wedge, at Albert Lea, on August 5th. The general ıd plan of the hopperdozer seemed to be good, but it was to be too heavy for practical work on a large scale. It was that the hopperdozer was much larger than necessary. As :rage height of the young trees which are most affected is ın four feet, we found that the bumper was too high, as it not touch the trees. We then lowered the bumper as low as d go—within six inches of the bottom of the hopperdozer—ˋsed the handles so it would allow the hopperdozer to swing six inches of the ground. In this way we were able to use the experiments. We found that the bumper was too far d, as it would strike a tree and cause it to bend forward and ›ther trees ahead, thus disturbing the leaf-hoppers before the lozer got to the trees on which they were, and shaking them arge numbers. We found that, by the trees being disturbed ı, fully nine-tenths of the hoppers escaped from the interior of the hopperdozer without touching it. Practically all vhich were caught were caught on the very front edges of ›perdozer. We found that the crude oil was not effective, hoppers did not seem to cling to it very well; but the tree oot caught practically all that came in contact with it.

: found that the canvas curtains at the back of the machine, hey were covered with the crude oil, daubed the leaves of the y stock; and it is doubtful if these curtains are of any value, hoppers did not seem to fly backward at all.

: following counts were made on the apple stock in the fter the hopperdozer had been run over the trees. Ten trees aken for each count, and in all but the first two cases every ree was taken.

r treated	10 trees, 7 young, 3 adults found on trees
next to treated row	10 trees, 59 young, 60 adults found on trees
treated	10 trees, 35 young, 12 adults found on trees
, next to treated row	10 trees, 42 young, 14 adults found on trees
, nine rows away from treat-rows	10 trees, 86 young, 42 adults found on trees

This would seem to show that, if the dozer had been so co
structed that the hoppers could not escape from its anterior e
this treatment would have been very effective. At this time, Se
tember 22d, a new hopperdozer is being built and developed fr
our experience with the one which we used at Albert Lea, and fr
points gained by talking with practical nurserymen. This sho
be of service another season.

Suggestions for Further Work.

It does not appear that the feeding habits of this hopper ha
been discussed heretofore. In the next report the manner of th
feeding on the under sides of the leaves, taking their nourishme
from the under sides of the leaves, and leaving the upper surfac
with more nourishment, thereby causing them to grow more rapid
than the under sides, and thus curling the leaves downward, and t
habit they have of always hiding on the under sides of any obj
on which they are placed, should all be discussed fully.

I have not seen a careful description of the different nymph
stages, though these have been figured if they have not be
described. A careful and distinguishing description of each sta
would be very desirable. A key to stages was made last summe

The egg-laying capacity of each female should be worked ou
if possible, and the proportion of the sexes at different seasons o
the year be determined.

It would be desirable to give a brief discussion of this commo
pest, and a statement of how it may be found and recognized b
farmers and others interested. Its predaceous enemies should b
studied. If it has parasitic enemies, they are evidently very scarc
as we have discovered none in our numerous experiments of thre
seasons.

Consideration should be given to the possibility of sprayin
with either Bordeaux mixture alone, or Bordeaux mixture an
resin, or fish oil soap, when the trees are in a dormant condition, o
at least before time of hatching of the winter eggs, in order t
cover the egg-blisters with a covering which might prevent th
hatching of the hoppers.

NTINUATION OF WORK WITH CABBAGE MAGGOT IN 1909.

A large amount of work, representing many experiments, was ied on in 1909. Much of this work resulted negatively, but is ned valuable in showing what is not effective, or what may be imental to the plants, although efficacious in keeping off the ggots. Much of this work is given here in detail.

Summarizing from results we can state that:

Tarred paper discs were found very effective. See p. 47.
Sawdust and glue were fairly efficacious, p. 49.
Treatment with carbolic acid emulsion, p. 54, gave excellent results. See also results with tobacco dust, p. 55.

On May 14th cauliflower plants were set out south of the insec- r. On May 18th a row of these cauliflowers, containing 51 nts, was treated with O. & W. Thum Company's tree tanglefoot and R2). This was applied by first melting the tanglefoot in a pail, and applying it around the bases of the plants on the ound, when it had cooled to a temperature of 130 degrees Fah. s probable that, before the application was finished, the tempera- e of the tanglefoot had got down as low as 110 degrees Fah. e tanglefoot was used at the rate of about one pound for 32 nts, and costs about 25 cents a pound, so that the material cost ittle less than one cent a plant; which would make the cost of terial for treatment of an acre extremely expensive. But the atment was carried on with the hope that material might be ained at less expense for this purpose if it was found to prove isfactory.

On May 28th this row was examined, and it was found that 38 of 51 plants used in the experiment, or about 75 per cent., had d on account of the treatment; but it was noticed that the plants od the treatment all right in case the tanglefoot was not placed on leading leaves. Of the 13 living plants 4 died later, so that June 15th only 9 healthy plants were left. These were pulled on June 15th, and all of them were almost entirely free from festation, and only three were infested at all. The general ults of the experiment may be said to be negative aside from owing that the tanglefoot will stop the maggots.

On May 19th cauliflowers, which had been planted below the iry Hall on May 14th, were also treated with O. & W. Thum o.'s tree tanglefoot (*Brand R2*). The tanglefoot had to be

heated several times during the application and each time it w heated to about 140 degrees Fah. At times the temperature g down as low as 115 degrees Fah. during the process of applicati In all there were 590 plants treated in this way, and 368 ch plants were included in the experiment. The tanglefoot was heat in the following manner: The pails containing it were placed in large kettle over a fire, and when melted up the tanglefoot w poured out into a pail and allowed to cool to a satisfactory temper ture, and then applied with a spoon. In this crude way much m tanglefoot was necessarily applied to the bases of the plants th should have been required, and so the expense was much great than it should have been. Furthermore, it was impossible to pla the tanglefoot exactly in the position that was desirable, and so great deal was daubed on the leading leaves, causing the death o the plants. It seems not altogether improbable that if a bett means of applying the tanglefoot (perhaps by some double-boil arrangement with a spout running out from it) could be devise that this material could be applied in such a way as to make th treatment not very expensive, and so that it would not harm th plants seriously. Also such a method of application might sav re-heating the tanglefoot several times, and so save time in applica tion. Pains were taken to surround the bases of the plants entirel with the tanglefoot on all sides, and have it run out a full inch away from the bases of the plants on every side.

On May 28th the plants in this experiment were examined, and it was found that, out of the 590 treated plants, 360 had been killed apparently by the tanglefoot treatment. The plants which ha survived were retained and examined from time to time, for the purpose of seeing if the tanglefoot could stop the maggots, even if it could be made otherwise successful.

It must be remembered, in figuring up the proportion of the plants which died in the treated rows, that a considerable number of plants also perished in the check rows, so that probably many plants would have died even if the tanglefoot had not killed them. The check rows had lost, by May 28th, about 40 out of the 368 plants. The plants in this experiment were pulled up, a few on June 9th, a few on June 10th, and a few on June 19th, but most of them were pulled up on June 21st and 22d. When pulled, they were examined, and the infested and non-infested ones of each row of treated and check plants were both counted. The total results were as follows:

Treated, 75 entirely free, 48 infested.
Check, 20 entirely free, 113 infested.

This count, however, does not tell the whole story, as among infested plants those which had been treated were much less sted, and much cleaner in appearance than were those which been untreated and were infested.

On June 18th the experiment was tried of dipping the middle tions of cauliflower plants in melted tanglefoot, and then drop- g them in water, and afterward setting them out in the field, it ig thought that possibly this method would be the best means applying the tanglefoot, as by this means very little tanglefoot ild be used, and it could be kept entirely away from the leading es. It necessarily, however, got down nearer to the roots by method of application. In addition in some cases cheap cotton ting was wrapped around the tanglefoot on these plants, as it thought the cotton might prove an added barrier to the mag- s, and at the same time make the operation of setting out less ectionable.

In these tests practically all of the treated plants died, while st of the check plants survived; and, in the case of the treated nts which survived, there was not much evidence in favor of the of this treatment against the maggots.

Experiments with Soot.

Cauliflower plants set out May 14th were treated on May 18th, placing a trowelful of dry soot around the bases of the plants. is covered the ground about the stem for a radius of about five hes. As the soot had become more or less blown away by the id, and mixed with dirt by rains, another application similar to first was made on the 28th; and, as this had become badly ked with dirt by June 2d, a lot of soot was mixed up with water, l the soot dough was applied around the bases of these plants. enty-seven of the plants in this experiment were pulled up and mined on June 10th, and 16 were pulled up and examined on ie 15th. Out of the total of 43 plants, 38 were found to be re or less infested by maggots, which shows that this treatment s not at all effective. Further than this, it was found that the nts in this row were badly troubled by cutworms; much worse n were other rows of cauliflowers treated differently. The cut- rms seemed to like to work into the soot, and they were found bedded in the soot in a large number of instances. At least one

cutworm was taken away from every plant in this row, except o or two, and in some cases as many as four were taken away fro single plant. It is probable that they took to the soot in this w on account of its black color, which caused it to absorb a great d of heat during the day and retain it during the night.

On June 3d a row of 81 cauliflower plants were set out, and June 4th every other plant in the row was treated with a batch soot dough placed around its base. The soot covered the grou for a distance of six inches away from the plants on every sid On June 22nd 27 of the plants were pulled up and examined, and July 20th 34 others were examined. Of the treated plants, were found to be infested and 14 free from infestation, and of t check plants 12 were found to be infested and 18 free; so t general results of the treatment with soot were negative.

Experiments with Lime.

A row of cabbages, planted on May 14th, had the alterna plants treated on May 18th with air-slaked lime, about a trowelfu of the lime being used around the base of each plant. This cover the ground around the stem of the cabbage for a radius of fou inches. The lime having become somewhat mixed with soil b rains, this treatment was repeated on May 28th. On June 17t 19 plants were pulled up and examined, and on August 20th th remaining 24 were pulled up and examined. The results wer entirely negative, as many of the treated plants, as of checks, bein found infested.

Experiments with Carbolic Acid and Lime.

Cauliflowers planted May 18th, belonging to Mr. Fisher, of S Anthony Park, were treated on May 20th with carbolic acid an lime; the formula given in the New Jersey Bulletin No. 200 bein followed. These plants were treated again in the same way o June 1st, a third time on June 16th, and the fourth time on Jun 26th. These plants were cultivated twice, the first time on the 28t of May, and the second on the 8th of June. On July 12th som of the plants had reached maturity, and Mr. Fisher began harvest ing them. On July 14th the roots of the cut plants were pulle and examined, and afterward the remaining roots were cut an examined every few days as the harvesting proceeded; examina tions and counts being made on the following days: July 16th July 24th, and August 3d. After the last counting the result

re added up, and we found that of the treated plants there had n 48 marked by the maggots, and six not marked, and of the cks 113 marked, and 13 free; two rows, one on either side of treated row, having been used as checks. From this standpoint, thing is shown in favor of the treatment. A few plants were t after the last count, but these were not examined, as the second od of maggots was now coming on, and any treatment would this time have fulfilled its purpose on the first brood.

On July 16th, after a portion of the plants in this field had been rvested, we counted the number of heads that were tied up, and o all that promised the development of marketable heads, in both check rows and the treated rows, with results as follows:

Check on one side.. 44 tied, 20 to be tied.
Treated ..... 58 tied, 21 to be tied.
Check other side.... 61 tied, 15 to be tied.

This shows but little, if anything, in favor of the treatment.

Experiments with Tarred Felt Discs.

Cauliflowers planted May 14th were treated with tarred felt scs, 825 plants having discs applied. These plants also belonged Mr. Fisher, of St. Anthony Park. These treated plants were three rows, and check rows were left between and on both sides them, so that the check and treated rows alternated. The discs ere bought already cut, and they cost $2 for the 825. It took ree men an hour to apply them to the plants.

On May 28th these plants were examined, and the discs were und badly covered up with dirt on account of the cultivation. he dirt was brushed off of the discs on this date. These plants ere cultivated on May 28th and again on June 7th. The cultivaon threw the soil over the rows in such a manner as to cover up e discs to a depth of a couple of inches or more. On June 15th e soil was again removed from the discs. As Mr. Fisher began harvest these plants on July 12th, and had thrown out the roots here they had dried up, we were unable to begin making counts ntil July 14th. The roots of plants which were small and did not ake heads were pulled up and examined, as well as the cut-off ots which were left in the ground by Mr. Fisher. Plants were lled up and examined on July 14th, 16th, 20th, 23d and August d. The plants had, as usual, a very marked difference in favor f the treatment, and a difference was noted throughout the count-

ing, but it became less and less noticeable toward the last, : second brood of maggots was beginning its work, and the dis by this time become so covered up and out of shape that the of little value. This will be shown best by the following c The count made on July 14th was as follows:

Treated	92 infested,	56 free.
Check	172 infested,	15 free.

AUGUST 3d.

Treated	19 infested.	1 free.
Check	23 infested.	0 free

Totalling the counts made on the dates above mention found of the treated plants 241 infested, 99 free; and of the c 346 infested, 37 free. It should be noted here, also, that the r roots in the treated rows were, as a rule, much less badly n than were those in the check rows. It will be noted that th number of counted plants does not equal anywhere near the n of plants first regarded as being included in the experiment. was due to the fact that Mr. Fisher had already harvested p the crop when we began counting, and that we left a part plants uncounted because it did not seem worth while to co the count further.

On July 16th we also counted the plants which were n able, and were likely to become so, which remained in the t and check rows at this date, part of the harvesting having done. The plants, the heads of which were tied up, were cc and the plants which had begun to develop heads and were and thrifty were also counted separately. The results of counts were as follows, the rows being given in the order o position, T denoting the treated rows, and C denoting the rows:

	Heads tied up.	Heads not tied up, but of good size.
C	62	21
T	82	27
C	68	20
T	50	21
C	42	5
T	60	13
C	41	5

This gives a total count as follows: (T) treated 129 tied, 61 ot tied, but in good condition—three rows. Check (C) 213 tied, 1 not tied—four rows. Reducing these figures to a comparative sis, we would have on the basis of three check rows instead of ur, at the same rate of infestation as was found to be present in e four, 160 tied plants and 38 headed but not tied, to be com- ired with 192 tied and 61 headed in the three treated rows. This ves a balance of 32 tied and 23 headed but not tied in favor of e treated plants in three rows, or a total of 55 heads saved in e treated rows, that is 55 heads saved by treating 825 plants. As ere are usually about 7,000 cauliflower plants to the acre, this ould mean a saving of about 467 heads an acre by this treatment. it it must be remembered that this was not a fair test, as the eatment was applied a considerable time after the plants were set it, and the discs were allowed to get badly covered up with earth r a considerable length of time. The regularity with which the eatment improved the rows to which it was applied is interesting id noticeable. Compare the results of the counts above given, the mber of heads in each of the check rows, with the treated row or ws next to it. This treatment must be considered by far the ost satisfactory of all those tried during the season, everything nsidered.

Experiments with Sawdust and Glue.

Cauliflowers planted on May 14th, belonging to Mr. Fisher, of t. Anthony Park. On May 22d 173 plants in this experiment ere treated with a preparation made as follows: Four pecks of awdust, 4 pounds of slaked lime, 4 pounds of hard glue, 4 gallons f water. The lime was mixed dry with the dry sawdust; the glue as dissolved in the water, which was first brought to the boiling oint, and then the glue and water were added to the lime and awdust and thoroughly stirred up. A handful of this preparation vas placed around each plant, covering the surface of the ground bout the stem of the plant for a radius of about three inches. The ows on either side of the treated row were used as checks. Two men applied this treatment to the 173 plants in about thirty minutes. The glue cost about 25 cents per pound, making the cost of the treatment about $1.25 for the 173 plants, which must be considered very expensive.

On June 15th a few of these plants were pulled up, and one out of every three were found to be badly infested. The plants were

cultivated on the 28th of May and on the 7th of June. Mr. Fisher began harvesting the cauliflowers in this patch on July 12th. We pulled up, examined and counted the roots of the plants from which the heads were cut from day to day, on the following dates: July 14th, 16th, 23d and August 3d; and, summing up the results of all these examinations and counts, we found of the treated plants 42 infested, and 6 free. This shows nothing in favor of the treatment. On July 14th the heads which were tied up and the plants which were large and in good condition and promised to become marketable, were all counted with results as follows:

Check on one side..	66 tied, 18 to be tied.
Treated row	20 tied, 5 to be tied.
Check on other side	21 tied, 6 to be tied.

The check row which had the largest number of good plants was twice as long as either the other check row or the treated row, so here again nothing is shown in favor of the treatment. The second check row was on the very margin of the field, and the plants could hardly be expected to be as thrifty there as in the other rows, in any case.

On June 12th three rows of young cauliflower plants were set out and treated with a sawdust-and-glue preparation, made up according to the formula in the New Jersey Bulletin No. 200. Alternate plants were treated, and the intermediate ones were left as checks. One row contained 67 plants, the second contained 65, and the third 47. On August 25th these plants were all pulled up and their roots examined, as follows:

Treated	21 free, 10 marked.
Checks	14 free, 37 marked.

This gives some evidence in favor of the treatment. Many check and treated plants died because of lack of moisture.

On June 15th two rows of cauliflowers were set out on the Station grounds, and treated at once with sawdust and glue, the following formula being used in the preparation of the mixture: Four pounds hard glue, 2 gallons water, 2 pecks sawdust. There were 63 plants in one row, and 59 in the other. Every other plant in both rows was treated, the alternating plants being used as checks. On August 25th the plants in this experiment were pulled, and their roots examined, with results as follows:

Treated	10 free, 18 marked.
Checks	2 free, 35 marked.

This gives considerable evidence in favor of the treatment. Many plants died on account of lack of moisture. The loss of plants was divided about equally between the treated and untreated plants.

Miscellaneous Treatments.

On May 31st four rows of cauliflower plants were set out on the Station ground, one row being used as a check, the others being treated on June 2d, as follows:

One row of 64 plants Dr. Franklin treated with air-slaked lime placed around the base of the plant about three inches in every direction; one row of 77 plants he treated with cotton batting wrapped around the base of the plant after it was set out, and being pushed down somewhat into the dirt and held down by the dirt being pressed around it. The cotton stood up from an inch to an inch and a half from the dirt, all the way around the plant. It took 8 cents worth of cotton to treat 101 plants. Another row of 57 plants was treated with cotton batting in a similar way, and one row of 59 plants was treated with cotton batting and creosoted sawdust. The cotton was applied as in the case of the other two rows, and the creosoted sawdust was placed around the cotton, but not allowed to come in contact with the plant tissue. On June 3d these rows were examined, but it was found that nearly all the plants treated with cotton batting and creosoted sawdust were dead, evidently on account of the creosoted sawdust. These plants were removed and fresh plants were put in their places, and these were treated with cotton batting as soon as set out, in a manner similar to the other two rows treated with cotton. On June 15th the row treated with lime was treated again. On August 9th the row treated with lime was pulled up, and the roots of all the plants examined with results as follows: Seventeen marked by maggots and four not marked. The check row was likewise examined on this date, with the following results: Thirteen marked and thirteen free from marks. This gives no evidence in favor of the lime treatment.

The plants in the three rows treated with cotton batting were also examined at this time, and there was no evidence shown in any of the rows in favor of the treatment. It should be noted here, however, that the cotton batting treatment in these experiments did not really have a fair chance to prove its value; as English sparrows from the first were a great nuisance in tearing away the

cotton and carrying it away for nest-building, and it had to be continually replaced, until finally tobacco was dusted on the cotton, after which the birds left it alone fairly well. This trial of cotton was hardly made with the expectation of its being practical for market gardeners, but in order to see whether or not it would act as a barrier in preventing the fly getting close enough to the plant to lay her eggs thereon. If it did we thought that some modification of this method, of real utility gardeners, might be denoted.

One row of 27 cauliflower plants was set out, partly on May 14th and partly on May 29th. It was treated with waxed paper and creosoted sawdust on June 2d. The paper was put around next to the plants, and the sawdust around that. The treatment injured the plants badly.

Another row of 42 plants, set out on May 29th, was treated similarly on June 2d, and on June 3d all plants were dead. Evidently creosoted sawdust cannot be used in any way for the cabbage maggot.

A row of 88 cauliflower plants was set out on June 3d, below the Dairy Hall. On the morning of June 4th every other plant in this row was treated with cotton, the cotton being wound around the stem of the plants and at the bottom pushed down in three or four places; the dirt being closed up to hold the cotton firmly down.

On the morning of June 7th these plants were examined, and it was found that the cotton had been torn away by the sparrows for nest-building. This occurred several times, and the damage had to be repaired, and finally tobacco was used for keeping the birds away. On June 22d the plants in this experiment were pulled up, and the roots examined, with results as follows:

Treated plants ..... 9 marked, 15 free.

Check plants ....18 marked, 13 entirely free from infestation,

—showing some advantage for the treatment.

A row of 80 cauliflower plants, set out on June 3d, was also treated with cotton, as described in the experiment just discussed. This experiment was also bothered by the birds. These plants were also pulled up on June 22d and examined, with results as follows:

Treated ..... 10 marked, 25 free.

Checks ..... 17 marked, 17 free.

-this, too, showing some advantage in favor of the treatment.

Cauliflower plants, set out on June 9th, had cotton wrapped around them when they were set out, so that the cotton was stuck down into the dirt about an inch, and above the soil about three-fourths of an inch. There were two rows treated in this way, the alternating plants being treated, on this date. In one row there were 76 plants, and in the other 88 plants. On August 25th the plants remaining in these rows were pulled up, and their roots examined. Out of the 164 plants, of the treated plants, only 22 were living. The death of the plants is not to be attributed to the treatment, because as many check plants as treated ones died, but to the fact that either the plants were in poor condition, or that they were not set out properly. Of the treated plants 3 were found to be free from infestation, and 8 had been marked by maggots. Of the check plants 5 were free from infestation and 6 had been marked by maggots. This gives no evidence in favor of the treatment.

On June 12th and 17th two rows of cauliflowers were set out with cotton wrapped around them, the cotton being stuck down into the dirt about an inch, and above the soil about three-quarters of an inch, as above described. These two rows contained in all 123 plants, alternating plants being treated in both rows. In the case of these two rows also there was no evidence to be found, when the plants were pulled up and examined, in favor of the treatment. On the whole it must be said that the cotton treatment was entirely unsatisfactory.

Treatment with Sulphur.

Two rows containing between them 185 plants were set out on June 4th on the Station grounds, and were treated with sulphur about the bases of their stems on the morning of June 6th. The alternating plants in these rows were treated, the remaining plants being left as checks. About half a trowelful of sulphur was used for each treated plant. The sulphur remained in good condition, unmixed with soil, as long as this experiment continued. It took 14 pounds of sulphur for 81 plants, making this treatment rather expensive. On July 12th the plants in these rows were pulled up and examined with results as follows:

Treated	**11 marked, 42 free.**
Check	**6 marked, 29 free.**

It will be noticed that many of the plants had died, apparently through poor condition, or on account of being improperly set, rather than on account of the treatment. This experiment showed no evidence in favor of the treatment.

Miscellaneous.

On June 9th a row of cauliflowers containing 86 plants was out on the Station grounds, the alternating plants being wrap in waxed papers about their middle portions, their roots extend below the paper, and the tops of the plants projecting above it. paper protruded about an inch above the ground, and was wrap tightly about the stalks, it having been folded before it was wrap so that there were three or four thicknesses of the paper betw the soil and the stalks of the plants. On August 25th the pl were pulled up and the roots examined and counted with res as follows:

Treated	**6 marked, 1 uninfested.**
Checks	**7 marked, 1 uninfested.**

This gives no evidence in favor of the treatment. It wil observed that the majority of the checks and treated plants died some reason aside from the treatment.

On June 15th a row of cauliflowers containing 34 plants set out, and all plants treated at once with hellebore decoction formula given in the Twelfth Report of the Minnesota State E mologist, Page 136). On June 22d these plants were treated a as before, and also again on July 20th; the long space of t between June 22d and July 20th having been allowed to pass w out treatment, because the maggots were at this time pas apparently into the pupal or adult stages, and were not active. August 26th the plants were pulled up, and the roots examined the following results:

Treated	**13 free, 31 marked.**
Checks	**2 free, 35 marked.**

(In another row, when set out of equal number.)

This shows some evidence in favor of the treatment.

Carbolic Acid Emulsion.

A row of cauliflowers containing 58 plants, set out on June 1 was treated *as soon as set out* with carbolic acid emulsion, n according to the formula given in Smith's New Jersey Bulletin 200. On June 22d this emulsion was applied again, and on 20th the plants were treated a third time. In this experiment a the one just described, there was no treatment applied betw June 22d and July 20th, because the maggots were not active. August 26th the plants were pulled up and the roots exami *with results* as follows:

Treated, 21 free from infestation, 13 marked by maggots.
Checks, in another row, 2 free, 35 marked.

Another check row, with an equal number of plants when set out, gave a count of 7 free, and 31 marked, which shows considerable evidence in favor of this treatment with carbolic acid emulsion.

Tobacco Dust.

On June 22d a row containing 37 plants of cauliflowers was set out. All the plants in this row were treated with tobacco dust, sifted around the stems as soon as set out, and again in a similar way on July 13th. On August 26th these plants were pulled up and examined, with results as follows:

Treated ..... 14 free from infestation, 2 marked.

A check row containing same number of plants gave a count of 7 free, and 31 marked, showing much evidence in favor of the treatment.

EXPERIMENTS WITH THE CABBAGE MAGGOT ON RADISHES, 1909.

The following experiments with the cabbage maggot on radishes indicate that hellebore decoction is useful as a deterrent. (See p. 55). Also carbolic acid emulsion, p. 56; and not only that the tobacco dust treatment is a good preventive, but that tobacco is a fine fertilizer for radishes, p. 57. Air-slaked lime injures radishes if applied liberally, see p. 57.

Radishes were planted on May 31st, in plots on the Station grounds as follows: Plot 1 contained 16 rows; plots 2 and 3 contained 14 rows each; plots 4 and 5 contained 15 rows each. Each row was 12 feet in length. Plot 4 was reserved as a check on the others. When the radishes began to show above ground, on June 3d, those in Plot 1 were treated, on June 8th, with hellebore decoction (see Twelfth Report of the Minnesota State Entomologist, Page 136, for the formula); the radishes at this time being one and a half inches high. Hellebore decoction was applied with a sprinkling can, without the rose, along the rows. The ground around the radishes was thoroughly moistened with the decoction. This plot was treated again on June 15th, a third time on June 19th, a fourth time on June 24th, and a fifth time on July 3d, after some of the radishes had been *pulled* and counted.

Plot 2 was treated with carbolic acid and lime on June 8th, the same date that Plot 1 was treated. The formula given in New Jersey Bulletin No. 200 was followed. This treatment was applied several times more on the following dates: June 15th, June 19th, June 25th, July 3d, July 23d; the last two applications being made after a part of the radishes had been pulled and examined.

Plot 3 was treated with sulphur on June 4th. The tallest of the plants were at this time between 1 and 1½ inches high. The sulphur was sprinkled very thickly along the rows, so as to completely surround the bases of all the plants. It took 45¾ pounds of sulphur to treat this plot. Of course, the expense of such treatment would be out of the question for radishes, but it was hoped by this application evidence might be obtained as to the value of sulphur as a preventive of cabbage-maggot attacks on cauliflowers, where a smaller amount of sulphur would be required for the returns expected.

Plot 5, on June 8th, was treated with an emulsion of carbolic acid and ivory soap. This, it will be noticed, was the date of the first treatment of plots 1 and 2. The carbolic acid emulsion was made up according to the formula given in N. J. Bulletin 200. This plot was treated again on June 12th, a third time on June 19th, a fourth time on June 24th, again on July 3d and July 23d—the last two times after the first radishes had been pulled and examined. The roots were pulled and examined in these plots as we got time for the work, as nearly as possible when they were large enough for table use in numbers, the dates being June 30th, July 17th and August 2d. The sum total of the counts made on these dates was as follows:

Plot 1	219 marked,	686 entirely free.
Plot 2	138 marked,	1,132 entirely free.
Plot 3	557 marked,	597 entirely free.
Plot 4	75 marked,	842 entirely free.
Plot 5	101 marked,	1,122 entirely free.

It will be seen that these results are somewhat questionable as far as the maggot is concerned, (see check row No. 4) due, possibly, to the fact that the maggots were not very active during the period when the radishes were in the ground.

Four plots of radishes, planted on June 4th, each containing 10 rows 9 feet long, were all contiguous with one another; plots 1 and 3 being check plots, and 2 and 4 being treated plots.

Plots 2 and 4 were treated on June 10th, when all the plants were about three-fourths of an inch high, with tobacco sifted along the rows in considerable quantity, so as to surround the stems of all the plants. It took eight pounds of the tobacco-dust to treat each of these plots in this way. On June 13th these two plots were again treated. On July 20th the radishes, which were of table size, were pulled, their roots examined and counted. Since the last treatment the maggots had apparently not been active. The untreated check plots were also pulled and the roots examined and counted on the same date:

Plot 1	755 entirely free,	489 marked by maggots.
Plot 2	952 entirely free,	299 marked by maggots.
Plot 3	1,022 entirely free,	200 marked by maggots.
Plot 4	1,269 entirely free,	119 marked by maggots.

This gives considerable evidence in favor of the tobacco treatment.

Two plots of radishes were planted on June 4th. Plot 1 contained 14 rows, each 10½ feet long, and plot 2, 15 rows, each 10½ feet long. Plot 2 was used as a check, and plot 1 was treated on June 8th with a uniform coating of air-slaked lime. It was again similarly treated on June 15th. It was found that the treatment was not going to give any particular results as regards keeping off the maggots, particularly because the maggots were not very active at that time. On July 19th radishes in both plots were pulled up, and those of table size were counted. This was to find out what effect the lime had on the growth of the radishes. The general appearance of the plots seemed to plainly indicate that the lime was detrimental to the radishes. It was found that plot 1 (the treated plot) contained 2,561 radishes of table size, and practically no small radishes were left after these were pulled and counted, while plot 2 (the check plot) contained 2,814 radishes of table size, and many radishes were still left which were too small for the table, the count proving conclusively that the lime was detrimental.

Plots of radishes were also treated with lime and oil of cloves, and with carbolic acid emulsion, and in every case the treatment was more or less, and in some cases, severely injurious. The radishes in all the plots of this season's experiments were Early Scarlet Globe.

On June 23d a radish plot was planted, containing eight
each 10½ feet long. On July 14th the odd, or alternating
in this plot were treated with tobacco-dust, the other rows bein
as checks. On August 12th all the radishes of table size i
plot were pulled and their roots examined, with the following
results: 521 roots from the odd or treated rows; 309 roots
the even or check rows—this showing the fertilizing value c
tobacco radishes. In the case of the treated radishes, there
102 showing marks of maggots, and 419 without such n
while of the check plants there were 51 showing maggot n
and 258 which did not, which shows no advantage, from the
got standpoint, in the treatment.

MINNESOTA NURSERY INSPECTION:
INSPECTION OF IMPORTED EUROPEAN STOCK.
1909 and 1910.

Our inspection of state nurseries appears to be on a satisfactory basis, at least for the time being. The state law, it is true, is somewhat lax; but, at a conference of some of our leading nurserymen and the entomologist, it was not thought advisable to attempt any change in 1911, in view of the possibility of a federal law in the near future. Letters from nurserymen not in attendance at this conference expressed practically the same views as those given at the meeting, namely, satisfaction with the present law and the way it was administered; with a feeling that no change should be made until something decidedly better should be offered in its place.

In 1909 nurseries looked vigorous and thrifty. The growth of apples, shrubs and canes was generally very striking, the best for years. There was plenty of apple aphis, though damage from this insect was slight. The apple leaf-hopper was also abundant; but the trees were making such a vigorous growth, before the hoppers put in an appearance, that growth was not materially checked. Other insects in evidence were the Poplar and Willow Beetle, *Melasoma scripta*, doing much damage in some of the Southern nurseries to young poplars, but easily kept in check by proper spraying with arsenate of lead; the Plum Curculio and Codling Moth in orchards; the Eight-spotted Forester, the Leaf-roller of the Basswood, *Pantographa limata*, the Fall Web Worm, the Oyster-shell Scale, and various leaf-eating caterpillars.

Mr. Ruggles, who did the inspection in 1909, also reported the following diseases in orchards and nurseries: Crown Gall on raspberries, Anthracnose on raspberries, Leaf Blight on box elder, Pear Blight (Fire Blight), Scab.

The crown gall on raspberries was very abundant. He reported it as being more abundant where plants had been disturbed than in beds not so disturbed, and advances the theory (which is perfectly possible) that the cutting away of the young plants, leaves wounds

where the bacteria, if present in the soil, may enter. Anthracn
was found in one nursery. Blight on box elder was not bad, nc
in only one nursery. The same was true of fire blight. Scab
quite noticeable wherever proper spraying had not been practi
We append a list of the nurseries inspected in 1909:

June	24	Faribault Nursery, O. F. Brand & Son, Faribault....	$3.00
"	24	Farmers' Seed Co., Faribault.....	3.00
"	24	Andrews' Nursery, Faribault	3.00
July	15	Howard Lake & Victor Nurseries, Howard Lake....	4.50
"	22	Jewell Nursery, Lake City.....	4.50
"	22	Tolleson Nursery, Lake City.....	3.00
"	22	Johnson Nursery, Lake City.....	3.00
"	26	Fred Cowles, West Concord	2.90
"	26	W. E. Fryer, Mantorville	2.90
"	26	F. E. Cutting, Byron	2.90
"	27	C. H. Ritter Berry Farm, Plainview.....	4.50
"	15	North Star Plant Farms, Cokato.....	3.25
"	15	Wright County Nursery, Cokato.....	3.25
Aug.	4	B. T. Hoyt, St. Paul.....	1.25
"	5	John Hawkins, Rose Hill Nursery, Minneapolis.....	1.50
"	7	Vine Grove Nursery, Minneapolis.....	2.60
"	7	J. W. Strand, Taylors Falls.....	4.56
"	9	A. O. Hawkins, Deep Haven Nursery, Wayzata.....	1.50
"	9	Chas. Hawkinson, Wayzata	1.50
"	10	W. A. Yahnke, Pleasant Valley Fruit Farm, Winona	4.75
"	11	Wm. Sandrock, R. R. No. 3, Rushford.....	4.75
"	12	C. E. Snyder, Preston	4.75
"	12	G. A. B. Howell, Spring Valley.....	4.75
"	13	J. M. Lindsay, Austin	4.25
"	13	C. F. Woodle, Austin	4.25
"	13	P. J. Regan, Twin City Nursery, Hopkins.....	2.50
"	14	L. L. May & Co., St. Paul.....	5.72
Aug.	16	L. D. Mills, Mills Lake Nursery, Lake Crystal.....	$4.85
"	16	L. E. Smith, Mankato	4.85
"	17	Norway Poplar Nursery, Emil Sahler, Waseca.....	6.35
"	17	Wm. Pfaender, Jr., New Ulm	4.85
"	20	R. P. Christensen, Hutchinson	4.56
"	20	Holm & Olson, St. Paul	2.25
"	20	Wedge Nursery, Albert Lea	3.00
"	20	Albert Lea Nursery, Albert Lea.....	2.00
"	20	Minnesota State Nursery, Albert Lea.....	2.00
"	20	Clinton Falls Nursery, Owatonna	4.25
"	20	Mitchell Nursery, Owatonna	3.25
"	20	Mayfield Nurseries, L. L. May & Co.....	....
"	23	S. D. Richardson & Son, Winnebago	4.00
"	23	P. C. Christensen, Fairmont	4.00
"	24	G. D. McKisson, Fairmont	4.00

				Cert. No.
"	24	B. E. St. John, Fairmont	4.00	315
"	24	E. J. Lewis, Jackson	4.50	316
"	24	L. Meininger, Sherburne	4.50	317
"	25	Kanaranzi Nurseries, Adrian	4.50	318
"	25	C. E. Older, Luverne	4.50	319
"	25	F. A. Ward, Pipestone	4.50	320
"	26	Lyon County Evergreen Nursery, Cottonwood	6.00	321
"	27	C. J. Orton, Marietta	6.00	322
"	28	E. Soholt, Madison	6.00	323
"	30	A. Wilwerding, Freeport	8.00	324
"	31	A. W. Patten, Mora	8.00	325
Sept.	3	C. H. Brady, Deerfield	4.50	326
"	14	Northwestern Nursery, Lake City	7.90	327
"	15	Brackett Nursery, Excelsior	1.15	328
"	15	A. A. Bost, Excelsior	1.15	329
"	15	Old Fashioned Flower Garden, Excelsior	1.15	330
"	15	Lyman's Nursery, Excelsior	1.15	331
"	15	Hennepin County Nursery, Eden Prairie	3.00	332
"	15	J. A. Flagstad & Sons, Sacred Heart	6.25	333
"	15	Elliott & Redpath Nursery, Crystal Bay	1.00	334
			$234.74	

This amount ($234.74) was deposited with the State Treasurer.

In 1910 we deputized Mr. F. J. Crider, a graduate of the Agricultural College and specialist in Horticulture and Entomology, to do the inspection. He was instructed to make careful examination for crown gall on raspberry, and to notify the nurserymen that where over ten per cent of plants were found infested a certificate would be denied until satisfactory assurance was given the inspector that said plants had been destroyed. We were obliged to refuse a certificate to a few of the growers until that had been done. He found, in addition to crown gall, some woolly aphis, an abundance of Buffalo tree-hoppers, and various plant-lice, twig-borers on box elders, the Striped Poplar Beetle, Oyster-shell Scale, Apple Leaf-hopper, Willow Scale, Lecanium Scales, and other insects of minor importance. Inspection of nurseries in 1910 occupied the time from June 8th to July 30th.

NURSERIES INSPECTED AND CERTIFICATES GRANTED IN SEASON OF 1910.

				Cert. No.
May	6	Peter Sivert, Canby	$17.50	335
June	6	Northwestern Nursery, Lake City	2.60	336
"	8	B. T. Hoyt, St. Paul	2.00	337
"	8	Rose Hill Nursery, Minneapolis	2.50	338
"	10	Vine Grove Nursery, Minneapolis	2.60	339
"	10	Holm & Olson, St. Paul	2.60	340
"	11	L. L. May & Co., St. Paul	5.80	341
"	13	Strand's Nursery, Taylors Falls	5.00	342
"	13	Chisago Lake Nursery, Lindstrom	5.00	343
"	14	Deephaven Nursery, Wayzata	2.50	344
"	14	Chas. Hawkinson, Wayzata	2.50	345
"	15	Hennepin Co. Nursery, Eden Prairie	3.00	346
"	15	Old Fashioned Flower Garden, Excelsior	1.30	347
"	15	Bracketts Nursery, Excelsior	1.30	348
"	16	Elliot & Metcalf, Crystal Bay	2.50	349
"	17	Howard Lake & Victor Nurseries	5.50	350
"	17	Wright Co. Nursery, Cokato	4.50	351
"	20	A. Wilwerding, Freeport	8.00	352
"	21	Oslund's Nursery, Cambridge	8.00	353
"	22	B. P. Christensen, Hutchinson	5.00	354
"	23	J. Flagstad & Son, Sacred Heart	6.50	355
"	24	M. Soholt, Madison	6.00	356
"	24	C. J. Orton, Marietta	6.00	357
July	1	C. E. Older, Luverne	6.00	358
"	2	Kanaranzi Nurseries, Adrian	6.00	359
"	5	E. J. Lewis, Jackson	5.00	360
"	5	P. C. Christensen, Fairmont	4.50	361
"	5	G. D. McKisson, Fairmont	4.60	362
"	6	B. E. St. John, Fairmont	4.55	363
"	6	S. D. Richardson & Son, Winnebago	5.00	364
"	7	Wedge Nursery, Albert Lea	3.50	365
"	7	Albert Lea Nursery, Albert Lea	2.00	366
"	7	Minnesota State Nursery, Albert Lea	2.00	367
"	8	J. M. Lindsay, Austin	5.00	368
"	12	G. A. B. Howell, Spring Valley	4.75	369
"	12	C. E. Snyder, Preston	4.75	370
"	13	Wm. Sandrock, Rushford	5.75	371
"	15	W. A. Yahnke, Winona	4.75	372
"	15	Tolleson Nursery, Lake City	4.00	373
"	15	Johnson Nursery, Lake City	3.00	374
"	15	National Nursery Co, Lake City	5.00	375
"	17	Mrs. Nils Anderson, Lake City	4.00	376
"	17	Jewell Nursery, Lake City	7.50	377
"	20	C. P. Nichols, Northfield	6.50	378
"	21	J. P. Andrews, Faribault	4.00	379
"	21	O. F. Strand & Son, Faribault	5.00	380

			Cert. No.
21	Farmers Seed Co., Faribault.....	6.00	381
22	L. Z. Smith, Mankato	3.00	382
22	Wm. Pfaender, New Ulm	4.00	383
25	Emil Sahler, Waseca	4.00	384
25	D. M. Mitchell, Owatonna	4.00	385
26	Clinton Falls Nursery, Owatonna.....	6.00	386
27	C. H. Brady, Medford	4.50	387
28	W. E. Fryer, Mantorville.....	3.00	388
28	F. E. Cutting, Byron	3.50	389
29	C. H. Ritter, Plainview	4.00	390
30	Fred Cowles, West Concord.....	3.50	391
ug. 30	J. V. Bailey, Newport.....	2.88	392
		$263.73	

is amount ($263.73) was deposited with the State Treasurer ceipt received for the same.

e following nurseries do not receive inspection (1910):

on, Adolph, Renville.
Chas. E., Albert Lea.
an, J. W., Cokato.
n, J. A., Faribault.
an, R. W., Plainview.
e, C. J., Lake City.
State Nursery, Albert Lea.
an, H. W., Le Roy.
ne, F. T., Crookston.
A. W., Elk River.
A. B., Excelsior.
County Evergreen Nursery, nwood.
en, Anthony, Madelia.
ger, L., Sherburn.
ake Nursery, Lake Crystal.
, C., R. F. D., Preston.
Mora Nursery, Mora.
Norden Nursery, Albert Lea.
John Osborn, Dassel.
Parker, W. L., Farmington.
Perry, P. M., Excelsior.
Perry, Frank, Stillwater.
Twin City Nursery, Hopkins.
Rochester Fruit & Plant Nursery, Rochester.
St. James Nursery, St. James.
Stephens, J. M., Crookston.
Tanner & Seager, Cannon Falls.
Taylor, G. D., Fulda.
Waird, G. L., LeRoy.
Windmiller & Co., Fred, Mankato.
Woodle, C. F., Austin.

e amount of foreign stock, from France, Holland and Bel- shipped into Minnesota is increasing each year. The amount y reaching us annually is surprising. In some instances seed- of varieties very common in Minnesota are imported, on the l that it is cheaper to pay the European price, transportation s and duty than to raise them here. For two years the State ologist of Minnesota, as in most other states, has been depu- y the Bureau of Entomology, at Washington, to examine all tock. The *day any European* stock leaves New York, con-

signed to Minnesota, advice is mailed this office, giving date of shipment, road and consignee. We thus know what is expected, and are on the lookout for these shipments. If they come through in bond, to be cleared at the Custom Houses in St. Paul or Minneapolis, the federal officials at such offices notify us (and they have been very courteous and helpful in this particular) of the arrival of the goods; we authorize the delivery of such stock after the other federal laws have been complied with, and at the same time notify the consignee, nurseryman or florist, as the case may be, and they comply with our request by telling us when the goods are at their institutions ready for examination. As a rule consignees are very obliging and helpful in the matter of examination, doing all in their power to facilitate the work; realizing it is to their advantage to get rid of any undesirable European pest, such as the Gypsy or Brown-tail Moth, and certain diseases peculiar to European pines, currants, etc.

The Simmons' bill, too long to be printed here, is to come before the present Congress. It provides "for the introduction of foreign nursery stock by permit only, and authorizes the Secretary of Agriculture to establish a quarantine against the importation and against transportation in inter-state commerce of diseased nursery stock, or nursery stock infested with injurious insects; and making an appropriation to carry the same into effect."

A few New York nurserymen are strongly opposing Sec. 8 of said bill, which reads as follows:

"Sec. 8. That whenever it shall appear to the Secretary of Agriculture that any nursery stock or other article described in section three of this Act grown in an infested country, district, department, or locality outside the United States, are being or are about to be imported into the United States, or the District of Columbia, and such nursery stock or other article is infested by any seriously injurious insect or disease which is liable to become established in the United States, he shall have authority to quarantine against such importations from said country, district, department, or locality and prevent the same until such time as it may appear to him that any such insect or disease has been exterminated or is under adequate control whereupon he may withdraw the quarantine."

The bill, with Sec. 8 retained, is being pushed by the Bureau of Entomology at Washington, and is supported in its original form

by the unanimous vote of the American Association of Economic Entomologists.*

From December 1, 1909 to December 1, 1910, we examined 376 cases of European plants imported into Minnesota; and of that number, 130 cases reached the state between July 1st and December 1st, 1910, showing the heaviest shipments to be in the spring. These 130 cases contained 11,080 plants, represented by 9,200 Azaleas, 200 hydrangeas, 75 rhododendrons, 662 palms, 570 syringas (lilacs), and enough other miscellaneous material to total the above figures.

We take this opportunity to express our appreciation of the courteous help received from the officers of the United States Customs of the Twin Cities, in connection with our examination of imported stock, and the almost universal politeness of our nurserymen and florists, who have extended much needed help in these examinations.

Abstract of Minnesota Horticultural Inspection Law.

We receive many inquiries regarding our nursery inspection law. The following points answer these questions, and practically represent an abstract of the law.

1. Inspection is not obligatory. Asked for by nurserymen in order to comply with the laws of states to which shipments are made.

2. The State Entomologist, however, has the legal authority to enter any grounds, public or private, where he has reason to believe that injurious insects or dangerous and contagious plant diseases exist, and if such pests are found there he may establish quarantine regulations or prescribe treatment of infested stock, or both, owner to pay costs.

3. Nursery stock entering Minnesota must be accompanied by a certificate of inspection on every package, signed by the proper

*As we go to press we learn that the Simmons bill has been killed for this session, through the active opposition of a few New York State nurserymen, led by Mr. Pitkin. It is a noteworthy fact that the nurserymen of the country at large are in favor of the provisions of the Simmons bill; but in spite of this, the opposition of a few prominent importers, referred to above —an opposition representing the private interests of a few individuals—has been sufficient to delay action, a delay which we believe is only temporary.

official in the state whence stock was shipped. Carrying companies transporting stock into Minnesota not so labeled are liable. Such certificate is generally honored by the Minnesota entomologist, but he has the right to demand that such shipment be inspected if he deems it necessary.

4. The State Entomologist has the right to revoke a certificate issued by him to a nurseryman when in the opinion of the entomologist there is just cause for so doing.

5. It will be seen from the reading of the above that stock imported from Europe into Minnesota comes under the provisions of the state act.

CERTIFICAT DE VISITE DE PÉPINIÈRES

RÉPUBLIQUE FRANÇAISE

Département du Calvados

CHAIRE DÉPARTEMENTALE D'AGRIC

DU CALVADOS

Le soussigné Professeur Départemen
culture de Caen, département du Calvad
désigné par M. le ministre de l'Agricult
ne avoir personnellement visité les pép
M. LEVAVASSEUR fils, pépiniérist
département du Calvados, le 25 Octob
après examen sérieux certifie que les
cultivés sont en excellent état de s
ne portent à ma connaissance aucu
trace d'insectes réputés dangereux,
traces de maladie cryptogramique sus
se transmettre dans d'autres pépini

Fait à Ussy, le 29 Octobre 1910.

Original déposé au CONSULAT DES E
LE HAVRE

Fig. 17A. Fac simile of certificate on package of French stock, wherein we found nest of Brown-tailed Moth

SAN JOSE SCALE POSSIBILITIES IN MINNESOTA.

IMPORTANT TO NURSERYMEN AND ORCHARDISTS.

The San Jose Scale, the most injurious insect to the fruit-raising interests in the United States, has been found in several localities in Wisconsin. In South Dakota this scale is known to have survived two winters, after which the stock affected was destroyed. In Minnesota we have experimentally carried it through two winters.

From the facts above stated it would appear that Minnesota fruit growers have reason to expect this pest sooner or later, and that it is unsafe for them, relying upon our cold winters, to congratulate themselves, on permanent immunity in this direction. In fact though it has never been reported to us, we have no doubt it could be found today in some of the older orchards of the state.

This scale, *Aspidiotus perniciosus* Comst., was brought to this country originally probably from China, over twenty years ago, and is now well distributed over the principal fruit producing sections in the United States. Not only do fruit trees and vines suffer, but almost all deciduous, ornamental shrubs and shade trees, as well as small fruits, and no insect has been the subject of so much and so strict legislation.

To the naked eye, the insect, when in numbers on the bark, is of a general grayish or black color. On badly infested trees it may completely cover the bark. Its presence on fruit causes a discoloration (a reddish mark about the scale), and when on the bark this red color can be observed below the surface in the cambium laver, if one removes the outer bark with a pen knife. In very bad cases the insects impart a greasy feeling to the bark which it covers.

The use of a magnifying-glass brings out certain features not visible to the naked eye. If the scale is thus enlarged ten or fifteen times, one sees that it is for the most part round, slightly raised above the bark and that the center (approximately) is occupied by a

tiny nipple-like elevation. This scaly covering, it must be understood, is simply an armor for the insect, which lives beneath, it being secreted by the insect. While the female scale is round, the male scale is generally somewhat oval. Under this armor, if we raise it carefully with a pen-knife, we find the yellowish insect with its long beak, with which it is enabled to reach and pierce the bark, even though it may be separated from the latter by one or more layers of its fellows.

Its Life History.

The young are born alive in the spring or summer, under the scale of the female, and crawl about for a few hours, after which they insert their beaks into the bark, and then, or even before, begin to secrete the waxy covering which we are wont to call the scale. It is during these few hours of active larval life that the young scales can and do migrate—one means of causing the pest each year to become more widespread. This migration may be active, to other limbs of the same tree, or to other trees whose branches interlace with the home tree, albeit they frequently settle close to the mother scale; or it may be passive, in that the young larvae are carried to other trees on the feet of birds, on the bodies of other insects, or possibly, to some extend, by the wind. Importation on infested nursery stock or scions (and this is the great danger in Minnesota) may be, and is frequently the cause of spreading this pest to a distance, and infested fruit has been, in the past, a very serious menace in districts to which it has been shipped.

The producing-period of the female is said to last for about six weeks, after which she dies. She begins to bring forth young when she is thirty days old, and under favorable climatic conditions may rear three broods or more. Both male and female, as well as the young, pass through the winter in the armored condition, as shown by our illustrations.

The Minnesota Experiment.

A few years ago at the request of a member of the Horticultural Society, we secured cuttings of fruit trees, loaded with this scale, from an infested state, and placed the same in securely-locked cheese-cloth cages, tying the infested scions to a healthy apple and plum tree in each case. The young spread from the scions to the trees.

perture was allowed during the spring and summer, on any of these cages, or at the lower edges. They were kept under and key, and no one but the writer had access to the trees n. In this connection it must be remembered that the young becomes fixed a few hours after birth. It is, therefore, only g this very short period that the danger of spreading the pest in the young stage. During the remainder of the year the are securely fastened to the tree. In the winter we have torn uslin from the top of the cage, thus exposing the insects to all r weather conditions. In both cages the scales survived the r of 1907-1908, and were so thrifty in the spring that they were ently the cause of the death of the trees in one cage. The scales cage naturally died after their food supply was cut off by the of the host-plants. The scales in the other cage went into r (1908-1909) in fairly good condition, but were found to be in the summer of 1909, as were also the trees.

Suggestions as to Preventive Measures and Methods.

owever faithful inspectors in scale-infested states may be, it is ntly quite impossible to completely prevent the exportation of scale insect. Minnesota nurserymen, orchardists and buyers namentals from any states south of us (as well as southeast and west) should look upon all such importations with suspicion. rding to our present inspection law we are obliged to honor icates issued by inspectors from other states who, as intimated , cannot completely eradicate the scale, however conscientious may be. For that reason we believe it would be wise for our ns, as a means of self-protection, to ask those from whom they urchasing stock to have their order fumigated before shipping. request on the part of purchasers is quite common. In case this done, a careful examination of the stock should be made upon rival and in case scale is found, or even if one does not find it, gation should be resorted to. We are glad to note that this has ly been done in the case of scions, by one of our progressive rymen. Not that the scale was found upon scions received by but it was regarded as a good precautionary measure.

ince the dipping of trees is now looked upon as dangerous, gation with hydrocyanic acid gas is regarded as by far the best od. The process is as follows: A house or box should be con- ed, containing a known number of cubic feet (100 cubic feet,

or some multiple of that number, is a good size). This is necessary in order to compute the amount of chemicals. A means of top ventilating from the outside should not be omitted. A false floor, if a house is used, or a false bottom, if a box is made, lattice-like in each case, should be so placed that the trees or scions can be placed thereon, an earthen crock or crockery bowl to hold the chemicals being placed beneath. Hydrocyanic acid gas is lighter than the atmosphere, and the reason for placing it below is to allow the fumes to ascend through the stock. Purchase the best of chemicals. The cyanide of potash should be 98 per cent purity, practically chemically pure, and the sulphuric acid should have a specific gravity of 1.83. *Do not use cheap chemicals*, and insist upon getting what you ask for. Wholesale houses in St. Paul can supply the proper materials. Cyanide costs about 25c per lb., sulphuric acid from 1c to 2c per lb.

If scions or roses or two-year-old apple or plum stock are to be fumigated, use the following proportions: Potassium cyanide, ⅔ oz.; sulphuric acid, 1½ ozs., and water 3 ozs. for every 100 cubic feet of enclosed space. Place the water in receptacle above referred to (never use a metal dish), add the acid, and then drop in the cyanide, immediately closing up the house or box. Allow it to remain closed for forty minutes, then open ventilator and air for 15 minutes before taking out stock. *Not only is cyanide of potash of itself very poisonous, but the above gas is deadly if breathed. Hence the need of extreme care in handling the cyanide, and in making the gas.* The former should be kept in an airtight receptacle plainly labeled "POISON," and out of the reach of children; and one should always bear in mind that when this cyanide comes in contact with the acid, a deadly gas is immediately given off, one good whiff of which might be fatal.

It is best that all stock be dry, or practically so, when fumigated. Do not fumigate stock which for any reason is dripping wet.

Spraying.

It is to be hoped that it may be some time before Minnesota orchardists have to spray for the San Jose Scale, but since there is a wash or spray which is most effective, not only for the San Jose Scale, but for all others, we give it herewith. It is known as the Boiled Lime Sulphur Wash, and it is to be used *only when the trees are dormant*. Make 18 pounds of powdered sulphur (flowers of sul-

phur) into a thick paste with water. Pour this into five gallons of hot water, in which twenty-one pounds of quick lime has been slaked. Boil with frequent stirring, for forty-five minutes, and add enough water to make fifty gallons. This amount could be reduced by reducing the proportions. Iron kettles may be used for boiling. The resulting mixture should be orange or yellow in color. Sometimes steam is used for boiling, and barrels are the containers. There is a method of making this wash without boiling, which, however, results in a less effective compound. It is made as follows: To about ten gallons of water in a barrel add 20 pounds of quick-lime, 15 pounds of sulphur and ten pounds of washing soda; stir frequently for half an hour, and add water to make fifty gallons. Both of these washes have caustic properties, and one should avoid allowing them to come in contact with the skin. Further, they act upon copper very quickly, and therefore, should never be placed in any receptacle made of that metal.

In spraying it is best to use a nozzle which produces a fine mist, The Vermorel or Mistry nozzles are both good for this purpose. A summer spray of lime-sulphur representing a much-diluted solution, 1-30, or 1-40, is being used with great success as a fungicide; and, in most respects, is far superior to the Bordeaux Mixture. When four pounds of Arsenate of Lead is added to 100 gallons of this dilute form, it makes a very good combined fungicide and insecticide. See in this connection the article on Spraying on page 143 of this report.

THE DANGER OF INTRODUCING THE GYPSY AND BROWN-TAIL MOTHS INTO MINNESOTA.

A Warning to Florists, Nurserymen and all Importers of Stock from France or Holland.

The danger of introducing these two European pests into Minnesota should not be regarded too lightly, and all parties importing stock should feel the necessity of affording the inspector every possible chance to see that no nest of Brown-Tail moth, or eggs of Gypsy moth are on the shrubs, plants, trees or vines purchased abroad. Not only would the florists' trade suffer, but all horticultural interests in this state would receive a serious setback if, through the indifference or neglect of an importer, either one or both of these pests should obtain a foothold here.

We are pleased to say that, with a few exceptions, all importers appear willing, not only to report the arrival of stock from abroad but to assist the inspector in every way possible. But it is well to remember that it would only require one case of neglect, possibly, to distribute these pests over the entire state and neighboring states.

The State Entomologist, who is also State Nursery Inspector, has been deputized by the Department of Agriculture at Washington to examine all imported stock coming into Minnesota. Every box of imported stock consigned to a shipping company at New York, and destined for parties in this state, is reported to him from Washington. Later, he receives notice from the collectors of customs in St. Paul and Minneapolis of such consignments as pass through their hands, and immediately communicates with the consignee.

The presence of a foreign certificate of inspection upon these boxes is no guarantee that the stock is clean. Particularly is this true of France, where the inspection, up to recent date, has been almost farcical. The French government has promised to better

these conditions. Inspection in Holland, on the other hand, under the direction of Prof. J. Ritzema Bos, appears to be very rigid. which may account for the fact that up to date we have found no indication of the presence of the Gypsy moth or Brown-Tail moth on stock imported into Minnesota, such stock coming almost entirely from Holland. At the same time even the Holland certificates have not been found infallible, and Dutch stock, as well as French, should be carefully examined upon its arrival. It may be well to add, however, that in many states, both eggs of the Gipsy moth and winter webs of Brown-Tail have been found in French importations this season. As illustrating certain dangerous conditions existing in France, we quote from a report of the chief of the U. S. Bureau of Entomology, Dr. Howard, upon a recent visit to that country.

"Nursery stock for export is, in many cases, grown in the vicinity of hedges and trees infested by Brown-Tail moths, by the Gypsy moth, and by other injurious insects as yet not introduced into the United States, and down to the present time there seem to have been no special precautions taken by nurserymen to prevent infestation of their nursery stock by injurious insects. It seems reasonably sure that the infested nursery stock imported last winter into the United States came from some regions as have just been described. In the late June and July flight of the adult Brown-Tail moths coming from hedges or woods adjoining nursery plantations many of these moths must have laid eggs upon the young nursery stock in the vicinity. These eggs hatched in August, the very small young larvae fed somewhat upon the leaves, webbed up into their characteristic winter nests, and were sent with the seedlings to America. The nests are noticeable, and only extreme carelessness, indifference, or ignorance on the part of the French exporters could have allowed them to be packed without removal."

We have found, in the course of an examination of imported stock, one nest of young Brown Tail moths, which was promptly taken care of. We do not believe that anything in the way of a European insect pest has slipped by us in our inspection of something over two hundred boxes in 1908 and 1909. If any specimens of Brown Tail moths or eggs of Gipsy moth have been introduced here, it is because of the thoughtlessness of some importer, who may have unpacked and distributed his stock without notifying us. There are doubtless but few cases of this kind, and it is probable that all florists, nurserymen, and other importers prefer to go to the slight inconvenience of notifying the State Inspector, and having him go over the stock at time of unpacking, rather than having a federal law created which *would oblige shipments to be unpacked and examined at port of entry, occasioning, frequently, delay and loss.* Let me then urge once more upon all importers of foreign nursery stock, trees or

ornamentals, in the interest of keeping the state free from these pests, and in the interest of good horticulture and floriculture, and for the sake of business prosperity, to notify the inspector at St. Anthony Park of the arrival of and time of unpacking of consignments from Europe.

To familiarize importers with the appearance of these two destructive pests in their various stages we append pictures of both of these insects in their various stages. We are indebted to Prof. E. D. Sanderson of the New Hampshire Experiment Station for the use of these cuts, and his courtesy is gratefully acknowledged.

Gypsy Moth.

Fig. 18.

Egg cluster; generally on bark of tree. Light yellowish. From August to May. Egg masses should be soaked with creosote in fall, winter or early spring.

Fig. 19.

Caterpillar: Dark color; double row of ten blue spots on back anteriorly, posteriorly twelve red spots.

Fig. 20.

Gypsy Moth, female: Moth whitish; wings imperfectly streaked with black or blackish; spread of wings about two inches. Does not fly.

Winter passed in egg stage. In this condition (Fig. 18) they are introduced into the United States.

Brown-Tail Moth.

Fig. 21.

Egg cluster on under side of leaf; dark yellow or brown; found in July.

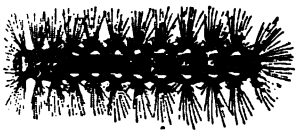

Fig. 22.

Caterpillar: Yellowish or orange. Row or white spots or markings along each side of body, middle line of back; posteriorly two bright, red spots.

Fig. 23.

Brown-tail Moth, female: Pure white, tip of abdomen brown. A strong flier, and attracted to lights.

Fig. 24.

Winter nest: Small caterpillars in mass of leaves and silk at ends of twigs, from which they emerge in the spring.

This is the stage (see Fig. 24) in which they reach Minnesota and other states on nursery stock and ornamentals, and is what the nurserymen and florists should look for, and what the inspector looks for at time of unpacking stock. THESE NESTS SHOULD BE CUT OFF AND BURNED IMMEDIATELY. IF LEFT ANY LENGTH OF TIME IN STOREROOM WHERE IT IS MODERATELY WARM THE CATERPILLARS MIGHT CRAWL OUT AND IN THAT WAY BE OVERLOOKED.

The Little Fly That Kills 75,000 American Babies a Year!

A fly is a very little thing.

But one fly has in a season 5,184,663,552,000,000,000 descendants.

It is bred in filth. It carries filth and germs into homes and deposits filth and disease germs upon the lips and bodies of babies and adults.

5,000 babies die every year in New York City from germs carried by flies.

75,000 babies die every year in the United States from the same cause!

In every generation 170,000,000 years of life—the equivalent of 4,000,000 lives of average length—are lost through the fly nuisance!

Over twenty billion dollars is spent every year for fly screens and other means of protection against the insect.—*American Examiner.*

O.

...Loth.

It is the intention of this division of the Experiment Station to issue circulars of information regarding our household pests—flies, fleas, clothes moths, cockroaches, etc. These circulars can be obtained free of charge by writing the Entomologist at the Experiment Station. The present circular is the first of the series.

The House Fly or "Typhoid Fly."

The name "Typhoid Fly" has been proposed for our common house fly because, although a large percentage of typhoid comes from our water supply, this insect, by carrying germs of typhoid and depositing the same on or in food, has been proved to be an

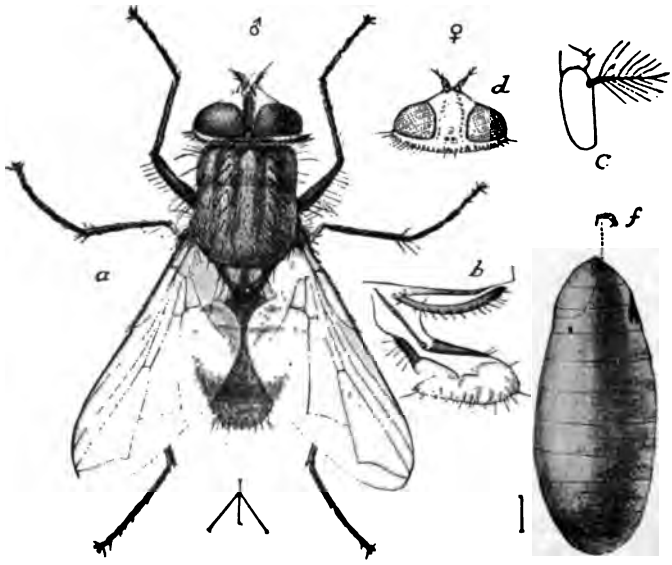

Fig. 26. The House Fly or Typhoid Fly. *a*, adult male; *b*, proboscis and palp of same; *c*, terminal joints of antennae; *d*, head of female; *e*, puparium; *f*, anterior *spiracle, all much enlarged.* After Howard, Bur. Ent., Dept. Agriculture.

:ans of spreading this disease. It is claimed that there is country annually over 200,000 cases of typhoid, about h of these cases resulting fatally.

Eggs of House Fly much enlarged. :alf, North Carolina Dept. of Agri-

Not only is this insect a menace to children and adults in this connection, but is also a disseminator of various other deadly diseases, such as cholera (the cholera germ as well as the typhoid germ having been found in fly-specks), tuberculosis and numerous other dangerous maladies. This filthy insect, then, is now known to be a serious menace to the health of human beings, and an active campaign has been inaugurated against it. The special danger of its presence in a house lies in the fact that in addition to the germs being able to pass through the aliment- and still retain their vitality, it can carry upon its feet and hairs of its body thousands of germs which, introduced into inal tract of man, may cause typhoid and other intestinal as well as consumption, and further be a cause of inocu- unds or abrasions upon the skin. It will therefore, be seen ıouse fly may be the means of transporting disease quite a and may possibly be the cause of an epidemic suddenly ap- ı a locality for which no reason can be assigned.

following quotation from a leading entomologist, while ant, is certainly suggestive, and deserves a place in any the house fly.

e course of a few moments a single fly might crawl over excre- from a glass of milk or water, and merrily chase across a dish of tatoes and other human food. It may visit a dead and decaying sport about the mouth of a reeking sewer, and in the next five

minutes sit upon the edge of a glass of jelly or alight in the sugar bowl. It may visit the body of an animal that has died of anthrax, and a little later brush across a lacerated hand or cheek."

Fig. 28. Larva or maggot of House Fly, natural size and enlarged. After Metcalf.

Bread, pastry, candy, fruit or vegetables exposed for sale without being covered, are subject to visits of flies, which may previously have crawled over the filth of the street or sewer or privy. An abundance of intestinal diseases is contemporaneous with the greatest abundance of the house fly, that is, during the hottest period of mid-summer, showing a connection between these two. As many as one hundred thousand bacteria, which came from matter voided from the intestine, have been found to be present on one fly. In our late war with Spain it was declared on reliable authority, and from actual data, that while we lost only two hundred and fifty men, practically, by bullets, we lost five thousand through the agency of house flies. This refers to criminal negligence in connection with the hospitals; the trenches containing the excrement of typhoid patients not being covered, and the flies, after crawling over this germ-laden matter, flying to the mess-tables of our soldiers, and polluting the food thereon.

Fig. 29. Puparium of House Fly, natural size and enlarged. After Metcalf.

The house fly passes the winter in some snug retreat, either as a perfect insect, or as a pupa, appearing on the scene in the first warm days of spring. The female lays a hundred or more eggs, each egg being about one-twentieth of an inch in length, which quickly hatch into maggots. These become full grown in about six days. The pupal or resting stage lasts six days. There are, therefore, from ten to twelve days from the egg to the perfect fly. They breed primarily in fresh horse-manure, hence the more of this waste that is allowed to accumulate, and the nearer it is to the dwelling house, the more will said dwelling house be troubled by flies. They also lay their eggs in other kinds of manure, in decaying vegetables, in sewage, in waste from the human intestine, and in various kinds of filth. They do not bite, but they lap or suck up food in a liquid state. When one sees a fly resembling a house fly on his hand, and

feels the sharp sting caused by the insect's biting or stabbing, he should realize that this is a stable fly, and not the house fly. Furthermore, when big flies and little flies are observed upon a window pane, the little flies are not to be regarded as the young of the big flies, but belong to different species, since flies and other insects never grow when they are in the final or perfect state.

Fig. 30. Petri dish containing agar over which a Fly, caught on the experiment station grounds, was allowed to walk. The white spots are colonies of bacteria coming from germs left by the Fly when crawling over the jelly. Original.

When we consider the filthy location of the eggs of the house fly and know its food, it is no wonder that we turn with disgust from any dining-room table where these creatures are in evidence, and we are not surprised that, after crawling over such filth, or over the saliva of a consumptive, they can and do carry the germs of typhoid and tuberculosis.

It is a matter for congratulation that the housekeepers of Minnesota are keenly alive to the desirability of keeping flies out of their houses. One occasionally finds a kitchen infested, or a dining-room infested, but as a rule our houses are well protected in this particular. It would seem, from facts in our possession, that to allow house flies to enter a dwelling-house or a hotel, amounts to almost criminal negligence.

Some Natural Enemies of the House Fly.

It addition to some insects which attack the Typhoid fly, such as the Dragon Flies, and the Robber Flies, which may make some inroads on their ranks, we find a tiny mite attacking them, as shown in Fig. 32, and in the autumn a very common fungous disease, the spores of which find suitable nourishment in their bodies. Flies killed by this desease, as shown in Fig. 31, are often seen hanging on window panes with this vegetable growth around them.

REMEDIES. Screens on windows and doors, sticky fly paper (preferable to poisoned fly-paper), the doing away with manure-heaps, the covering of slops and of filth, not leaving them to pollute the neighborhood of the house. Swill barrels should have tight covers. Some farmer's wives put sticky fly paper on the outside of their screen doors at the top and this catches the flies which gather on the doors. Intestinal discharges from a patient suffering from

Fig. 31. Fly killed by a fungous growth.

Fig. 32. Fly attacked by mites. Lugger.

typhoid or any other fever, or any infectious disease, should be sterilized before being emptied into sewer or cesspool. Stables should be, where possible, located at a distance from the house. A reason for not letting horse manure accumulate is very evident, and some stables are so constructed that this is kept in a covered compartment until removed, or treated frequently with a [illegible]ce which will kill the maggots of the house fly. The follow[illegible]n we h[illegible] to be good and at the same time sterili[illegible]vo of formaldehyde in a pint of water [illegible] not buy groceries or meats from any [illegible] Fruits and candies shou[illegible]en from the baby or its m[illegible]

SPEAKING OF FLIES!!

DON'T ALLOW FLIES IN YOUR HOUSE.
DON'T PERMIT THEM NEAR YOUR FOOD—ESPECIALLY MILK.
DON'T BUY FOODSTUFFS WHERE FLIES ARE TOLERATED.
DON'T EAT WHERE FLIES HAVE ACCESS TO THE FOOD.
Flies are the most dangerous insects known to man.
Flies are the filthiest of all vermin. They are born in filth, live on filth and carry filth around with them. They are maggots before they are flies.
Flies are known to be carriers of millions of death-dealing disease germs. They leave some of these germs wherever they alight.
Flies may infect the food you eat. They come to your kitchen or to your dining table, fresh from the privy vault, from the garbage box, from the manure pile, from the cuspidor, from decaying animal or vegetable matter, or from the contagious sick room with this sort of filth on their feet and in their bodies, and they deposit it on your food, and YOU DO swallow filth from privy vaults, etc., etc., if you eat food that has come in contact with flies.
Flies may infect you with tuberculosis, typhoid fever, scarlet fever, diphtheria, and other infectious diseases. They have the habit of feasting on tuberculosis sputum and other discharges of those sick with infectious diseases, and then going direct to your food, to your drink, to the lips of your sleeping child, or perhaps to a small open wound on your hands or face. When germs are deposited in milk they multiply very fast; therefore milk should never be exposed to flies.
What To Do To Get Rid of Flies.
Screen your windows and doors. Do it early before fly time and keep screens up until snow falls.
Screen all food, especially milk. Do not eat food that has been in contact with flies.
Screen the baby's bed and keep flies away from the baby's bottle, the baby's food and the baby's "comforter".
Keep flies away from the sick, especially those ill with typhoid fever, scarlet fever, diphtheria and tuberculosis. Screen the patient's bed. Kill every fly that enters the sick room. Immediately disinfect and dispose of all discharges.
Catch the flies as fast as they appear. Use liquid poisons, sticky fly papers and traps.
Place this fly poison in saucers throughout the house: Two teaspoonfuls of formaldehyde in a pint of water, sweetened with sugar.
To quickly clear rooms of flies, burn pyrethrum powder. Sprinkle the powder on live coals carried on a metal shovel. The fumes cause flies to fall in a stunned condition. They must then be swept up and destroyed. Best results are obtained by darkening the room, allowing only ray of light to enter at edge of window shade. Flies, in attempting to escape the fumes, will seek ray of light at windows. This simplifies their collection.
Eliminate the Breeding Places of Flies.
Flies breed in filth.
Allow no filth or decaying matter of any kind to accumulate on or near your premises.
Sprinkle kerosene over garbage and contents of privy vaults. Keep garbage receptacles tightly covered; clean the cans every day, the boxes at least every week. Keep the ground around garbage boxes clean.
Keep manure in screened pit or tightly covered vault. MANURE SHOULD BE REMOVED EVERY WEEK, AT LEAST.
Burn all refuse—such as old bedding, paper, straw, etc.
Pour kerosene into the drains. Keep sewerage system in good order; repair all leaks immediately.
Clean cuspidors every day. Keep 5 per cent solution of carbolic acid in them all the time. Get rid of sawdust boxes used as cuspidors – they're insanitary.
Permit no dirt to accumulate in corners, behind doors, back of radiators, under stoves, etc.
FLIES IN THE HOME INDICATE A CARELESS HOUSEKEEPER.
REMEMBER: NO DIRT—NO FLIES.
If there is a nuisance in the neighborhood notify the
Department of Health,
City of Chicago.
CONSUMPTIVE'S SPITTOON
GARBAGE CAN
TYPHOID
(BORDER ILLUSTRATION ADOPTED FROM FLORIDA STATE BOARD OF HEALTH POSTER)

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gation. Pyrethrum placed in a pan on a hot stove and allowed to smolder but not break into flame, will stupefy, if the room is tightly closed, all the flies therein, which should be carefully swept up afterward and burned, otherwise some will revive. Pyrethrum or Persian insect-powder loses its strength upon being kept; and in buying one should be particular to get fresh powder, or what has been kept in tightly sealed receptacles.

The House Fly is a menace to the health of your children and yourself. Its new name—"Typhoid Fly," is significant!

THE CLOTHES MOTH.

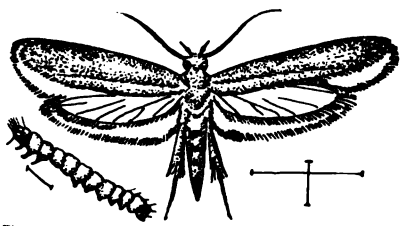


Fig. 33. Southern clothes moth. *Tineola bisselliella* and larva or "worm," enlarged. Lines on right show natural size of moth with wings spread. After Riley.

There are two species of clothes moth common in different parts of the United States, but we have come in contact with only one in Miniesota, namely, *Tineola biselliella*. This pale yellowish moth is about a quarter of an inch long, and its larva attacks not only woolens and furs, but also feathers. The writer has observed the moth flying in his residence as early as March 6th. It undoubtedly lays its eggs prior to that date, since full grown larvae were found on March 16th. The egg is visible to the naked eye, and can be dislodged by shaking or brushing the cloth or fur in which it is found. Eggs kept under observation in our laboratory, hatched in six and seven days, one female laying several eggs. One of these eggs measured under the microscope was found to be .02 of an inch long by .01 of an inch wide, of a pearly-white color. The young worm, or larva shown in Fig. 35, was one-twentieth of an inch long when about twenty-four hours old.

This is a very troublesome pest in Minnesota, as all housekeepers know. It is well to remember that camphor, naphthaline, moth balls, etc., kill neither the insect nor its eggs, but act merely as repellents. Further, storing furs and woolens in a chest, cedar or otherwise, the odor of which may be repulsive to the insect, would be of no avail if there were eggs or larvae of this moth in the

same when so stored. As a rule clothes, which are u
sionally or brushed or shaken in order to dislodge any egg
are not appreciably injured. If the presence of eggs or
suspected in any fur or other material, a mild beating and
of such article will remove most or all of them. Woole
hanging in an unvisited part of the attic, or rugs and simila
stored away and not examined frequently are prolific s
breeding moths in a house.

When one is absolutely sure that no eggs or larvae
are present, a very good practice is to store articles in
boxes which are afterward thoroughly sealed by pasting
the cracks. It is usually not safe to let woolens, furs o
remain undisturbed a long time in an ordinary trunk, s
rule, such trunks are not moth-proof.

Cold storage is much resorted to for the preservatio
during the summer, and this is quite a feature in the b
many of the cold storage plants in cities. The pest canno
a temperature below 40 degrees Fahr. Frequent beatin

serve to keep the former tight. Into this receptacle in the spring goes all of our clothing not to be used during the summer, and which is attractive to moths. At the same time in a saucer-like dish placed on top of the clothing is poured four tablespoonfuls of bisulphide of carbon, and the chest closed. It should not be opened for any purpose for three or four days. We repeat this performance about ten days later, since the vapor fatal to the larva does not, we believe, kill the egg, and perhaps once or twice more at intervals during the summer. These latter fumigations are probably not necessary, but would kill any insect life, should a moth, by accident, have crawled in. This vapor, heavier than air, sinks through the clothes stored in the chest. It is explosive when mixed with the atmosphere, and no light of any kind should be brought near it. Bisulphide of carbon may be purchased in pint cans. It in no way injures the clothes. A tight closet made for the purpose or any perfectly tight chest might take the place of the iron box above described.

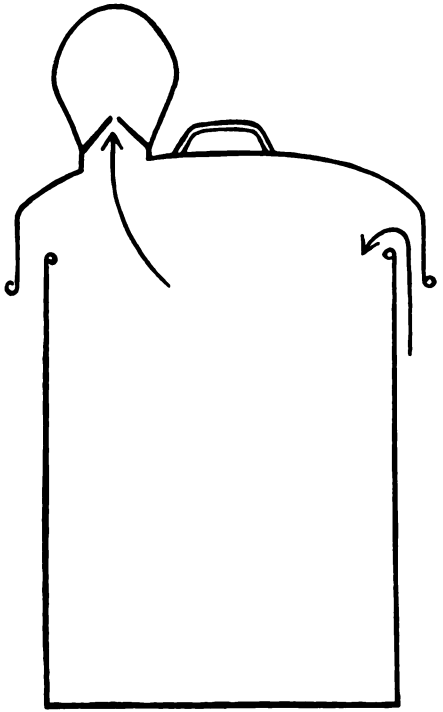


Fig. 37. Diagrammatic vertical section of "Hodge's Fly Trap."

Fig. 38. A new suggestion as to Fly Traps. The garbage can is so constructed that flies can enter. Then, they fly into the cage above. Hodge.

FURTHER WORK UPON THE STALK BORERS.

Papaipema sp.

Fig. 38. General view of plots used in experiments with Stalk Borers.

The eggs mentioned and figured on page 153 of the Twelfth Report were laid on or about September 17, 1908. On September 22nd they had become brownish gray in color. On Sept. 26th they were photographed; the photograph being the one that appeared in the Twelfth Report. On May 20th, 1909, these eggs began to turn dark, and on May 24th and 25th a considerable number of them hatched. Many of the caterpillars made their way to the leaves of seedlings of the giant bur-elder which happened to be in the cage, and in these leaves they acted as leaf miners, making galleries. Drawings of this first work of *Papaipema* larvae were made, and also photographs taken by Mr. Ayer. These galleries were made in

the middle of the leaves, the seedlings being scarcely one inch tall at this time. A drawing of one of the young worms was also made. They were about 2½ mm. long at this time. In hatching they left large holes in the sides of the egg-shells. These eggs continued to hatch until the 29th of May, and there were in all about 100 caterpillars which hatched from them, and the leaves of several young giant bur-elder seedlings, which were in the breeding-cage at the time, were completely riddled by the mining of these caterpillars.

The caterpillars in their earlier stages have a looping movement, much like that of *Geometrid* larvae. All the larvae, which had not

Fig. 39. Partial view of plots used in experiments, showing barriers, etc.

at this time established themselves as miners in the leaves of seedlings, were taken and placed on selected seedlings of giant bur-elder; these seedlings being all in good condition on May 28th. The larvae were placed on these seedlings at about 5:30 P. M. on May 28th, and were examined about 8 A. M. May 29th, and were found to have already established considerable galleries in the leaves of the seedlings. There were eighty-four larvae in all placed upon seedlings in this way.

Some of the leaves were photographed, showing the leaf-mining *work, with* mines well formed, and some of the larvae in them.

1 June 2d the larvae were show-
a noticeable tendency to work
1 toward the bases of the leaf
s, and even to work into the leaf
les to a considerable extent. The
st of the giant bur-elders were
: four inches tall at this time.
es showing this mining work,
:wo of the larvae, were bottled
:ohol and formalin. By June 4th
ırvae had in many cases taken to
g into the stalks of the young
lders, the tallest of the weeds
is time being about five inches
nd about one-tenth inch through
: base. By July 7th many of the
plants attacked were dead, hav-
een completely destroyed by the

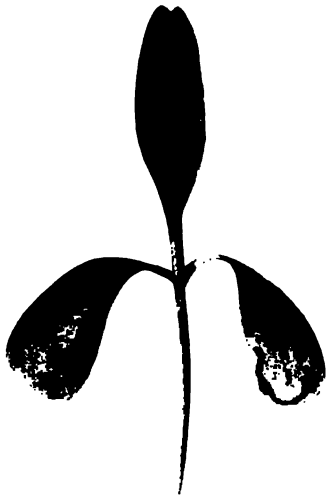


Fig. 40. The larva of *Papaipema* sp. mining in leaf of Giant bur-elder seedling. Franklin.

41. Larvae of *Papaipema* sp., mining in
flet shown in Fig. 40, much enlarged.
anklin.

borers, and many of the borers were in their second plants. The stalks of the second plants attacked were at this time about twenty-four inches long on the average, and the galleries in them averaged about four inches in length, ranging from two and one-half inches to six inches. By July 22d the caterpillars had reached a length of from one inch to one and one-quarter inch, the galleries much longer than the longest ones were on July 7th. One plant was found harboring two of the caterpillars. Its stem at this date was twenty-three inches long. The entrance

hole of the lower caterpillar was nine inches above the ground, and the upper one was thirteen and one-half inches above, and the galleries went upward from the entrance-holes. On August 17th none of the larvae which had been reared from the eggs were found present in any of the plants. Some of the borer holes were entirely vacant, and a few had pupae in them. This shows that a *Papaipema nitela* larva naturally attacks but two plants in the course of its life.

Papaipema nitela.

The last larva of this species seen during the season died in captivity on September 7th, twenty days later than the last larva pupated in the season of 1908. The first pupa was found on August 11th (three days later than last year). The first moth of this species emerged in captivity on August 24th (one week earlier than last year). The last moth emerged on October 1st.

The average length of the pupal stage this year was about the same as it worked out to be last season. This season it varied from twenty to twenty-six days, the average being twenty-three days. This species was reared during the season from the following food-plants: Nicotiana, Lamb's Quarter, Tomato, Giant Ragweed, Cockle Burr, Giant Bur-Elder, Peony, Burdock (the Giant Bur-Elder was this year, the same as last, the most badly attacked food-plant).

Typical *Papaipema nitela* larvae were found in the stalks of giant ragweed as follows: One with an entrance-hole ten inches from the ground, burrow seven inches long, ascending. This was found on August 1st. Two larvae of this species were found in giant ragweed with their entrance-holes twenty-one inches above the ground, and with burrows five inches long, ascending, and three were found on the same date with the entrance-holes six feet above the ground, and burrows three and one half inches long, and also ascending. On August 1st there were found twelve *Papaipema nitela* larvae in a single giant ragweed stalk three feet high. Some were in the stalk proper, and some were in the branches. We found many burrows formed apparently by both *Papaipema nitela* and *Papaipema cataphracta* larvae in wild hemp and other plants on September 3d. This goes to show that a large percentage of the larvae of these species go into the ground to pupate. The burrows which were formed earliest were at this date nearly closed up by the growth of the plant on the interior of the stem.

Papaipema cataphracta.

vae were first found working on young box elders on July From this date on they were found very commonly through- ir active season. The last larva found pupated in captivity ust 23d. The first pupa of this species was found on August vo days earlier than the earliest date last year). The first ı captivity emerged on August 30th (nine days earlier than ır), and the last one on September 27th (five days later than ır). This species was this year reared from the following lants: Burdock, Box Elder, Giant Bur Elder, Hollyhock, ;, Peony, Larkspur, Dahlia, Thistle, Aster, Ragweed and Lilies. Strange to say, it was not found at all this year in Hemp or Golden Glow. It was found in greatest numbers in k, as it also was in 1908. The average number of days passed ıupal stage, as computed from the records of a large number viduals this year, was twenty-nine, the range being from six to thirty-three. It will be noticed that this is quite a little than last year's average of twenty-two days (see Twelfth of the Minnesota State Entomologist).

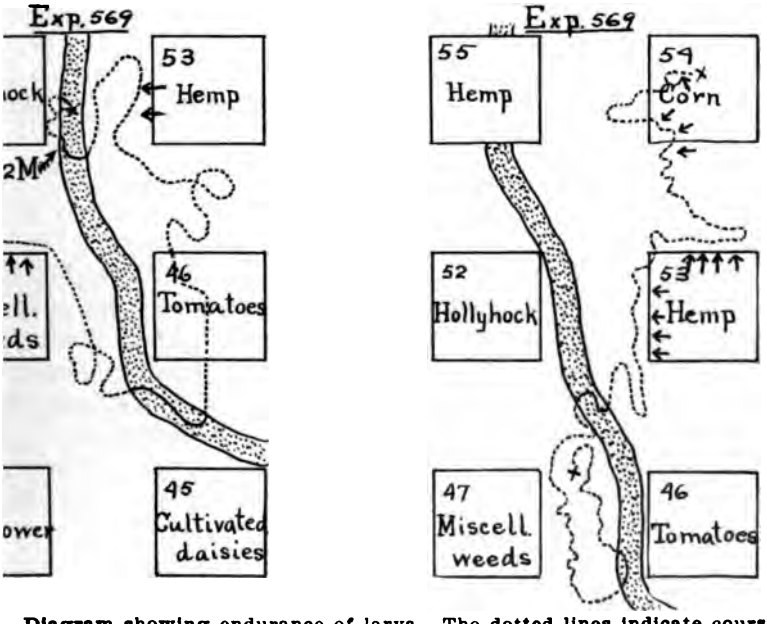


Diagram showing endurance of larva. The dotted lines indicate course arvae. Each plot 4 feet square. The broad shaded line represents a :h, about 10 inches wide. The arrows show where effort was necessary va from entering favorite food plants.

The specimens of this species found in thistle were observed to always enter at the bases of the leading leaves at the summits of the stalks, and to bore downward; the burrows at their lower extremities ending blindly. A Hollyhock stalk containing two larvae of this species were discovered, which had three entrance holes in it. The lowest of these was one foot from the ground, and the highest was four feet, two inches from the ground. All these openings were connected by one continuous burrow, which was three feet, five inches long. Both larvae measured at this time about one and one-fourth inches long. The burrow did not extend at all below the lowest hole, this showing that the larvae had, as is usual with *Papaipema* larvae, burrowed upward.

General Observations.

Larvae were placed upon various kinds of ground, and their movements watched for several hours, in many cases until many of the larvae stopped from exhaustion, and finally died without being allowed to enter the food-plant. These observations go to show that the larvae seldom, if ever, travel any considerable distance in a straight line from the place where they first hatch.

In tracing the course of these larvae, and in measuring the distances traveled, the courses were marked out as they traveled along, by lime scattered on the ground. The caterpillar which made the best record in actual distance traveled seventy-nine feet before exhausted, but when it finished its traveling it was only fourteen feet in actual distance from its starting-point, its course having been very irregular. Another larva traveled in actual distance fifty-six feet before being exhausted, but reached a distance of only sixteen and one-half feet from its starting-point. Still another traveled a total distance of fifty-five feet, and ended twenty-four feet from its starting-point, this being the farthest distance reached from the starting-point of which we have record. The larvae that made these records were practically full grown. See Fig. 42.

Fig. 43. Larva of *P. nitela*, taken from leaf mine, enlarged about 12 times. Original.

Observations Made in Parks of Minneapolis and St. Paul.

Several days were spent in examining flower-beds in parks of Minneapolis and St. Paul, all the principal parks being visited. In

most cases the beds were found to be entirely free from the attacks of stalk borers; and when they were not free, it was because the infested beds were located in some neglected corner of the park, near some weedy patch; it being evident in these cases that the larvae had first hatched from eggs laid on the weeds, and later found their way into the cultivated flower-beds. In talking with those who had charge of the flower-beds, we discovered that these beds were given far better attention than is commonly given to flower-beds of private individuals. Most of the perennials in the flower-beds of the parks are either taken up in the fall and put out again in the spring, or else—in the case of such plants as Golden Glow, which are left out-doors during the winter—the beds are raked very carefully, and the old dead stalks and stubble all destroyed late in the fall; and, of course, this treatment would naturally get rid of the eggs of any insect which might have been laid upon them during the early fall.

This, together with the observations on the number of stalks infested by a single caterpillar, and on the distance to which caterpillars travel, makes it very evident that the best means of combating these pests is to take good care of the beds; cleaning them up well late in the fall, after time of egg-laying of this species is over, and clearing up the weeds and keeping them cleared up in the vicinity of flower-beds. It is particularly desirable to clear up the weeds that start during the latter part of May, and during June, in such localities, because then the young larvae, which are at that time mining the leaves of the small weeds, are easily destroyed, and if the young weeds are destroyed in the vicinity of the beds at this time it is not likely that larvae will go from other weeds at great distances to attack plants in the beds. Of course, many private gardens are so placed that the matter of weeds is one which is difficult to control, because the flower-gardens are in close proximity to land belonging to other persons than the owner of the flower-gardens, and in such cases the owner of the flower-garden cannot go upon the other person's land and clean up his weeds for him. In such cases it is desirable to have some means at hand by which the borers may be kept out of the flower-garden, in spite of the proximity of the weedy places.

Experiments have been conducted, during the season, to discover some means of preventing larvae from getting into flower-beds in this way. Many different plots, adjoining different sorts of plants which are commonly infested by these borers, were laid

out. Some were used as check plots, and some were surrounded by various barriers to keep out the larvae. The plots contained the following food plans: Hemp, Peony, Dahlia, Corn, Potatoes, Tomatoes, Golden Glow, Asters, Tiger Lilies, Hollyhocks, Giant Bur Elder, Giant Ragweed, Burdock, Daisies and Sunflowers. Amongst the barriers tried were strips of lime six inches wide thrown around the entire plot; ditches dug with perpendicular faces next to the plots all the way round; tarred paper strips surrounding the plots, laid flat on the ground, six inches wide, covered with tangle-foot; galvanized iron strips stuck in the ground edgewise, alone, and painted with tar, painted with tangle-foot; shingles stuck in the ground endwise and overlapping one another, completely surrounding the plots alone, and painted with tar, with tangle-foot; plots also completely surrounded by strips of creosoted sawdust, six inches wide; one-eighth inch boards edgewise, alone, and painted with tar and tangle-foot.

Fig. 44. Pupa of *P. nitela.* Original.

Larvae were placed amongst these plots and were allowed to crawl around, and were watched; and it was found that only those barriers which had a coating of tangle-foot in some form were successful in stopping them. It was also found that only barriers which extended about three inches above the ground kept the tangle-foot free enough from dirt for any length of time to be of value. The shingles had a tendency to get out of place badly, leaving cracks between them; and it was found that, everything considered, the best barrier was one made of thin boards about five inches wide, about one-eighth of an inch thick, placed in the ground edgewise, and smeared with tangle-foot on the side away from the plot. Plots of ground were also surrounded with these barriers, and the painting with tanglefoot, tar, etc., reversed, being placed on the inside, and the caterpillars placed on the inside, to see if they could get out of the plot over the barriers; and here, too, the only thing which was capable of stopping them satisfactorily was a complete barrier like the thin board smeared with tangle-foot. It was noticeable that the caterpillars which were placed among the plots in the insectary garden, and their movements watched for some time, would, when within about two feet of their favorite food-plants, show a very strong determination to go

Fig. 45. Pupa of *P. cataphracta.* Original.

directly toward the food-plants, and they had to be continually turned away from them. This suggests that possibly a barrier of weeds might be placed around a garden in a regular line, thus providing the caterpillars hatched outside the garden with food, and so making it unnecessary for them to travel to the flower-beds. Of course, these weeds would have to be burned in the fall and others be set out in the spring sometime during the last of May or early part of June, and the stumps of these weeds would have to be destroyed in the fall, so that there should be no trace of them on which the moths could lay their eggs at that time of the year.

Fig. 46. Imago of *P. cataphracta*. Original.

Summary.

Provided one's garden is free of weeds, particularly burdock, ragweed, bur-elder and the like, and last season's growth has been carefully removed and destroyed, one can protect an entire garden from the attacks of the stalk-borer by a six or eight-inch board placed around the outside, the lower edge an inch or more below the surface of the ground, and the upper edge three inches above the ground; said board to have on the outside a band of some material which will either remain sticky or be kept sticky by separate applications, from June 1st to August 1st. Tangle-foot has proven satisfactory in our experiments. The tangle-foot should be put on an inch or so above the ground, so that it could not be easily coated with earth by the spattering occasioned in the event of heavy showers; and whatever sticky substance is used, it should be of such a nature as to either remain sticky, or be kept sticky by several applications, from June 1st to August 1st.

The fact that the larvae show a strong tendency, when within about two feet of their favorite food-plants, to go to said food-plants directly, suggests that possibly a barrier of weeds might be placed around a garden, thus providing the caterpillars outside the garden with food, and making it unnecessary for them to travel to the flower-beds. These would have to be burned in the fall, of

course. They would have to be in position during the last of May or early part of June.

In some cases it might not seem desirable to treat a whole flower-bed, or a whole garden, for these stalk-borers, and it might only be desirable to prevent their getting at a few plants which might be decidedly more valuable than the rest. In such cases it has been found that the bases of the stalks of the plants may be smeared with tangle-foot for a distance of about three and a half inches up from the ground. In such cases if there are leaves around the base of the plant, or (if the tops of the plant lie against other plants near by) these portions of the plant which would allow caterpillars to crawl from the ground over the tangle-foot, or from other plants on to the protected plant, should be cut away and destroyed.

Parasites.

These two species appear to be extensively parasitized, since we have reared many individuals of Tachinids from them. From *P. cataphracta, Hypostena variabilis Coq.*, and from *P. nitela* also, an *Exorista sp.*, also *Masicera myoidaea Desv.* in large numbers; the last named being identified by Professor Aldrich. From a breeding-cage containing both species we reared what I regard as *Ichneumon lactus,* and evidently *Ichneumon orpheus* Cress. From some material emerging from the pupa of *P. nitela,* Professor Aldrich also named for us an Ortalid, *Chaetopsis aenaea* Wied.

We have considerably more parasitic material from these two species, of at least one genus and parasitic.

Dr. Franklin had charge of this work and the above represents his report in this connection.

NOTES ON THE ENGLISH GRAIN PLANT LOUSE.

Macrosiphum granaria, Buck.

This is the louse which is so common on wheat in Minnesota. Specimens of this species were kept under observation during the fall of 1908, up to December 10th, and as late as this a large number of specimens, kept under natural out-door conditions, were still found to be alive. No males were found at this time. Only wingless viviparous females were present, and young females in all stages; no eggs were found.

The insects had been kept on winter wheat, and the temperature had been down at this time as low as five degrees Fah. below zero. These insects were kept on for some time after this, but in time succumbed to the cold weather, and all perished.

On April 5th, 1909, a considerable amount of sod from a field of winter rye, which during the late fall of 1908 had been very heavily infested all over with *Macrosiphum*, with the soil for four inches below it, was brought into the insectary, and put in a tight but airy cage, built for the purpose of stout pieces of wood and muslin. It was put near the center of the warm room of the insectary. This was kept and examined as late as June 30th, and no *Macrosiphum* appeared.

The material brought in from the rye-field completely covered the ground underneath this case, and the fact that the cage was 3 feet 4 inches wide by 6 feet 5 inches long, showed that a considerable quantity of sod and soil was brought in.

While the material in this cage was being so closely watched, the rye-field from which the material came was also examined and swept from time to time in April; then every few days during May, up to as late as the 25th, but no *Macrosiphum* was found in the field until May 29th. On this date Mr. Stafford, by sweeping with a fine collecting-net, captured an immature wingless nymph on the west side of the rye-field. On May 31st Mr. Stafford collected

five specimens by sweeping this field. Most of these were winged. On June 2d he collected seven winged and one nearly mature wingless specimen of this species, and on June 4th, he collected four winged and one wingless by sweeping. On June 9th he collected one winged and one-half grown nymph by sweeping with a collector's net. There had been recent rains, and insects of all kinds were scarce on the rye on this date. On June 12th three winged and one wingless *Macrosiphum* were collected. On June 14th a considerable amount of sweeping failed to collect any specimens. On June 15th twelve wingless forms were found by sweeping. On June 21st seven wingless forms were found, but no winged forms. On June 25th a dozen wingless forms in all stages, and one winged adult were found, and on this date the first colony was discovered by examining the rye without the aid of the collector's net. After this the rye was examined and swept from time to time with about the same results as before, only a very few specimens being found, and on July 24th, the rye having been cut on July 21st, the field was examined for the last time. The stubble was swept with a net thoroughly, but we were utterly unable to find any *Macrosiphum*. The shocks of rye and stubble were perfectly dry at this time.

The fact that so few *Macrosiphum* appeared in this field after the heavy infestation of the previous fall, and the fact that we were unable to rear any specimens from the sod and earth brought in from this field in a cage in the insectary, leads us to have some belief in the theory that this species comes in from the South every year, and that it does not pass the winter in Minnesota in any form. The early date on which it was found would make it seem probable that, if it does come in this way, it is brought in from long distances by winds. But if this is the case it must have been brought in, this season, in rather small numbers, as the numerous sweepings in the rye-field indicate.

On April 15th two shields of canvas, each 5x8 feet, were placed on the water-tank of the Experiment Station. In this position they were sixty feet above the ground, and as the tank is located on a hill, they were considerably higher than most of the surrounding country. These shields were covered with tree tangle-foot. The purpose of placing the shields in this position was to find out what sorts of insects were carried by the wind in considerable numbers, and to discover if *Macrosiphum* was among them. The shields were examined from day to day until July 6th, when the tangle-foot

had become so dried as to be of little use. Insects of many different kinds were found, but no plant-lice among them.

A similar canvas shield was raised on a frame of iron piping, on May 10th, on the southeast corner of the rye-field above mentioned. The shield was faced to the southeast, and held in place with ropes attached to the iron frame. This was examined from time to time up to July 13th. Insects of many different kinds were found upon it; among them, on June 25th, many winged specimens of aphid, *Callipterus punctata,* which breeds on oak. As there were no oaks within 300 yards of the shield, these plant-lice must have been carried a considerable distance directly by the wind. No *Macrosiphum,* however, were found on this shield at any time.

On July 15th a new shield was placed on the tower, in the position occupied by the old ones above described, and was examined from time to time up to September 8th; but no aphids were found at any time upon it, so that the work with these shields, as far as plant-lice in general and *Macrosiphum* in particular are concerned, is mostly negative.

THREE BAD INSECTS IN MINNESOTA NURSERIES AND ORCHARDS.

The Oyster-shell Scale or Apple-bark Louse, the Scurfy Sc and the Buffalo Tree Hopper.

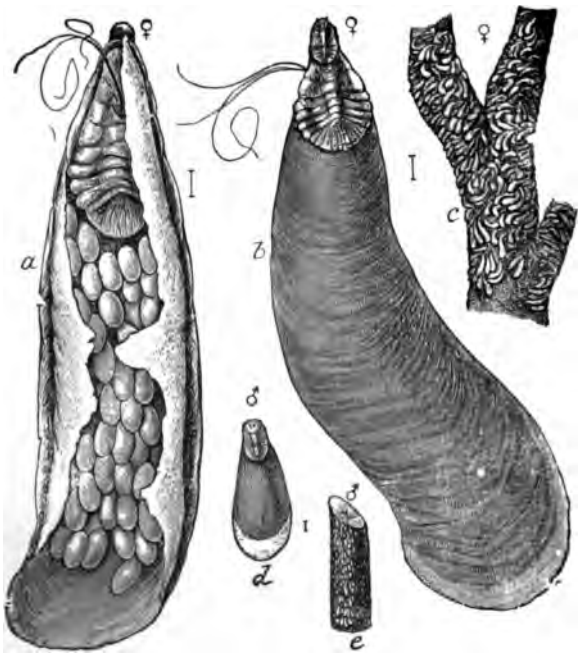


Fig. 47. The Oyster Shell Scale. After Bureau of Entomology, U. S. Dept. Agriculture.

The Oyster-Shell Scale and the Scurfy Scale appear to be the increase in this state, and both capable of injuring the tree: *the nurseryman* and the orchardist.

The first named, brownish in color, is at once recognized by its elongated "oyster-shaped" appearance. It infests not only the apple, but other fruit trees, as well as lilacs and various other ornamentals. The eggs pass through the winter under the scale, and hatch in the spring—May or June in Minnesota. The tiny young crawl over the tree for a few hours, and then become fixed, and secrete the scale which is to cover them for the remainder of their existence.

Spraying with a strong lime-sulphur solution, at a time when the trees are dormant, has been recommended: but perhaps as good or a better way is to spray several times with a mild lime-sulphur solution, or with kerosene emulsion, or with so-called whale oil soap, at the time when the young scales are crawling over the tree. A very effective thing to do would be to employ both the winter and spring sprayings. In this connection see the article on spraying, page 143.

Fig. 48. The Scurfy Scale.

The Scurfy Scale, *Chionaspis furfurus* Fitch, deserves notice here, although mentioned in the Twelfth Report. Both it and the previous scale appear to have become much more abundant since the printing of the last report in 1908. The Scurfy Scale gives no

trunks and branches of affected trees a "scurfy" appearance. The scale is oval, somewhat elongated, about one-tenth of an inch long, pointed at one end, and white. In addition to the apple, it affects pears where such are grown, also poplar, cottonwood, mountain ash, willow and other trees and shrubs. A closely-allied form is found on the elm. The life-history is much like that of the Oyster-shell Scale, and the same remedial measures are advocated.

The Buffalo Tree-hopper, *Ceresa bubalus,* Fab., is the cause of much complaint, reaching this division from nurserymen and orchardists. The illustration gives a fairly good idea of this queer-looking insect. We also insert figure of twig, showing the work of the female in laying her eggs. Fruit-growers frequently attribute these scars to hail. This work, of course, weakens the twig or branch. Further, any wounds made by insects of this class, or by tree-crickets, cicadas, or borers, must render the cane, shrub, or tree, as the case may be, more susceptible to attack of fungous or bacterial disease.

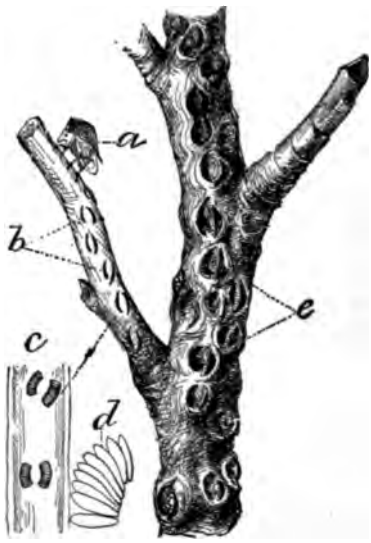


Fig. 49. The Buffalo Tree-hopper. After Marlatt, Bureau of Entomology, U. S. Dept. Agriculture.

We believe egg-laying takes place in this latitude during the latter part of summer, the eggs hatching the following spring. Consequently, where judicious pruning can be resorted to, it is a good plan to go over the trees in winter or late fall, trim out the affected portions as far as can be done without deforming the tree, and burn the cuttings. Orchards and nurseries should be kept clean and free from weed growth. The usual accepted methods of spraying for insects and fungi are of some help in connection with this insect.

THE STATE AND FEDERAL INSECTICIDE LAWS.

Two years ago Minnsota had no law governing the manufacture and sale of Paris green or arsenate of lead. In 1909 the Entomologist assisted in framing the following bill, which became a law through the action of the Legislature at its thirty-sixth session:

A BILL FOR AN ACT TO PREVENT DECEPTION IN THE SALE OF "PARIS GREEN" AND OTHER INSECTICIDES.

Be it enacted by the Legislature of the State of Minnesota:

Sec. 1. Whoever shall expose for sale or sell within this state any "Paris green" or other insecticide which does not conform to all the requirements of this act, or which is labeled or marked in any manner so as to tend to deceive the purchaser as to its nature or composition, or which is not accurately labeled as hereinafter required, shall be guilty of a misdemeanor, and for each offense shall, upon conviction thereof, be punished by a fine of not less than twenty-five dollars, and not more than one hundred dollars, or by imprisonment in the county jail not exceeding sixty days.

Sec. 2. The term insecticide, as used in this act, shall include "Paris green" and any other substance or mixture of substances intended to be used for preventing, destroying, repelling or mitigating any and all insects which may infest vegetation.

Sec. 3. Any insecticide labeled, marked or called "Paris green", shall contain at least fifty per cent of arsenious oxide *in combination with copper*, not more of water-soluble arsenic than the equivalent of three and one half per cent arsenious oxide, and no substance that would injuriously affect its strength or quality. And any insecticide labeled and called lead arsenate or arsenate of lead must contain at least fifty per cent of actual lead arsenate, at least twelve and one-half per cent of arsenious oxide, and no added substances that would injuriously affect the quality or strength.

Sec. 4. The label required by this act shall clearly and distinctly state the name and residence of the manufacturer of the "Paris green" or other insecticide, or the distributor thereof, or of the party for whom the same is manufactured and show the name, and with substantial accuracy, the percentage of each ingredient, both solid and liquid, contained therein; said label shall be printed in the English language, in plain legible type.

Sec. 5. The having in possession by any person, firm or corporation dealing in said articles, any article or substance hereinbefore described and

not properly labeled, as provided in this act, shall be considered *prima facie* evidence that the same is kept by such person, or firm, in violation of the provisions of this act and punishable under it.

Sec. 6. The Dairy and Food Commissioner of the state is charged with the proper enforcement of all of the provisions of this act.

Sec. 7. The said Commissioner and his assistants, experts, chemists and agents shall be duly authorized for the purpose, and shall have access and ingress to all the places of business, factories, stores and buildings used for the manufacture or sale of such "Paris green" or other insecticide. They shall also have power and authority to open any package, can, or other receptacle containing such "Paris green" or other insecticide, that may be sold, manufactured or exposed for sale in violations of the provisions of this act.

Sec. 8. This act shall take effect and be in force from and after August 1st, 1909.

Congress has also created a law, in no way repealing or infringing on our state law, imposing severe penalties for the introduction into any state or territory, or into the District of Columbia, or from any foreign country, or for shipment to any foreign country of any insecticide or fungicide which is adulterated or misbranded within the meaning of the act.

Government officials are proving to be aggressive in punishing violators of United States law, and it is believed that this law will be of great service to fruit-growers.

Should any insecticide be manufactured and sold within our state borders, our state law will take care of it, and if any is imported into Minnesota, both the state and federal laws will insure protection to our fruit-growers in this connection. The penalties for infringement of the federal law are quite severe, and this law is noticeably more strict than the state law, in that it applies to any substance or mixture of substances intended for use against insects infesting "vegetation, man or other animals, or households, or which shall be present in any environment whatever," (the same latitude being given to fungicides) while the state law only applies to insecticides against insects affecting vegetation.

FOUR INJURIOUS SHADE TREE AND TIMBER PESTS.

Maple Borers, Elm Borer (Saperda tridentata), Birch-Leaf Skeletonizer, Box Elder Twig Borer, Larch Saw Fly.

Fig. 50. Elm tree dying from attacks of Elm Borer. Original.

The year 1910 has been an exceptionally bad one as regar borers and other pests on shade trees. Some of the finest elms i the Twin Cities have either died from the attacks of the Elm Bore or have had their certain death anticipated by a free use of the a in order to save other trees not yet attacked. The Elm Borer pe forates the bark, loosening it from the underlying wood, and bor on the surface of the wood under the bark. This pest can easi

Fig. 51. **Work of** Elm Tree Borer. Tree in fore-ground killed. Original.

girdle a tree in this way, and hosts of elms in Minnesota have thus been killed. Frequently exudations, sometimes in the form of gum, and more or less of sawdust-like castings, will mark on the surface of the bark the opening of a burrow. This exuding matter from the burrow appears to attract ants; and we have sometimes detected the presence of this borer in an elm by first noticing the ants ascending its trunk. The deadly work of this insect begins to show itself in midsummer, though a tree-owner might not realize the fatal character of the attack until the following spring; when, perhaps, by the branches not leafing out properly, and by the generally diseased appearance of an affected tree, one realizes that something very serious is the matter. The branches die, sometimes even in the fall following the attack, and it is only a question of time—short at that—when the tree, which has taken so long to grow, succumbs to the work of an insect hardly more than an inch long. We found in Minneapolis, on April 20th, 1910, trees dying from the previous summer's attack, and containing at that date larvae of this beetle, of various ages, and pupae almost ready to emerge; indicating that the adult beetles would begin to emerge very shortly, possibly by May 1st or earlier, and continue to emerge during the summer, mating and laying their eggs on neighboring elms possibly not hitherto affected; dooming them, also, to a premature death. These facts are significant; for, when one finds trees evidently beyond cure, on account of the work of this borer, radical treatment is demanded. *Such trees should be cut down in winter or very early spring, and not piled up for firewood, thus allowing the beetles to mature and carry on their destructive work, but burned, trunk and branches at once, destroying all the beetles therein in whatever stage they may occur.* This should be done by park boards or other authorized officials, since individual owners are apt to neglect this important measure, thus allowing the pest to spread to the trees of their neighbors. Trees cut down in the late fall or early winter, might safely be used for firewood during that winter, but should be all burned before April 1st.

To protect trees not already attacked, or not severely injured, I would suggest several applications, beginning not later than May 1st, and repeating at intervals during the summer, of a compound composed of thick whitewash to which crude carbolic acid has been added at the rate of 1 quart of crude acid for every pailful of whitewash, and arsenate of lead, about six pounds for every fifty gallons of the wash. This wash could be colored with lampblack, making it grey and inconspicuous. It would, of course, brush off on the clothes of those touching the trees. This should be applied with a white-wash brush, over the trunk and the lower portions of the larger branches.

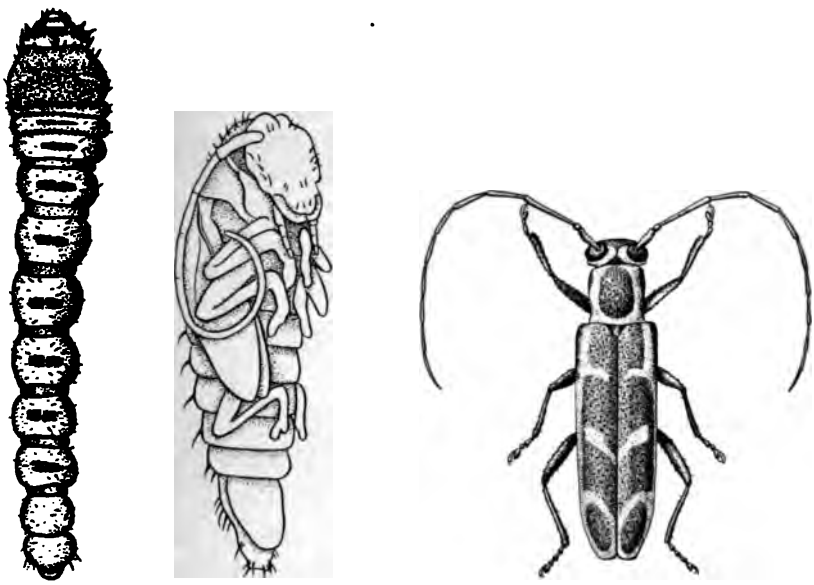
Fig. 32. A near view of work Tree Borer. Original.

The larval borers, found in the burrows, are white and somewhat flattened. The beetles are brown, with a red stripe on the outer edge of each wing-cover, from which stripe three to projections of the same color project toward the center of th

We find in our notes a record of finding this pest as l as November 9th, 1908, on which date we collected borer the trunks of five trees on the corner of 27th Street and 1st South, Minneapolis. They were most numerous close to the In one tree they were numerous enough to have easily kille

1909 injuries from this pest materially increased, and large n

of trees in various parts of Minneapolis were found to be seriously infested. In some instances of infestation there were suggestions of injury by gas (bark peeled off around lower portions of trunks),



Figs. 53, 54, 55. The Elm Borer, *S. Tridentata*, larva, pupa, imago. Original.

and in the 1908 instance referred to there had been two leaks in a gas-main near the injured trees, and our assistant thought that the trees may have been injured by gas primarily, and that the borers came as a result of the gas injury. We have reared this same borer, *S. tridentata*, from Poplars.

Flat-headed Borers, all Buprestids—which may possibly prove, when reared, to be more than one genus—were extremely injurious to maples in 1910, and bid fair to become established as a prominent and destructive enemy of these valuable shade trees. Not having yet reared these larvae, we are not sure either of the genus or species, and hence, cannot speak with certainty of their life-history. It is probable, however, that they issue as adults in spring and summer. Such being the case, and from what observations we have been able to make to date, we would advise the cutting down in fall or winter *or very early* spring, of all trees which are evi-

dently doomed to die by these borers, and anointing the trunks and larger branches of trees in the neighborhood with some repellent wash, which is at the same time poisonous. The Minneapolis Park Board have been using a wash composed of whale-oil soap and arsenate of lead; the poison, of course, being for the purpose of killing any young larvae which may hatch and start to bore into the tree after the application. Further, if a tree is old, and the bark consequently rough, the old bark should be scraped off as far as practicable, so that the wash could be applied to the smooth bark below. As in the case of the elm-borer, maple trees cut down on account of the presence of borers should not be piled for firewood. but should be either used for fuel immediately or completely destroyed by fire. In order to secure prompt attention in this matter, since infested trees are a menace, the cutting down and destruction of such trees should be in the hands of some authorized official or officials, whose business it is to act quickly and intelligently in such cases.

The Birch Leaf Skeletonizer, *Bucculatrix canadensisella* has, in 1909 and 1910, proved itself a serious shade-tree pest, and we have received reports of its injuries from Duluth, Two Harbors, Northome, Margie and elsewhere. This insect, in its injurious larval stage, is a delicate, slender green caterpillar, with a brownish head. The green of its body may be inclined to yellowish. It is nearly or quite one-fourth of an inch in length when full grown, tapering slightly at anterior and posterior ends. It may lower itself from a leaf, when disturbed, by a silken thread. It spins a brownish or yellowish cocoon less than one-fourth of an inch in length, and attaches it to leaf or twig. From this cocoon emerges a brown moth not half an inch long, whose wings are crossed with delicate white bars. The larva feeds upon the softer parts of the leaves, and this leaves a brownish skeleton; in other words, it "skeletonizes" the leaves. The injury is conspicuous in the latter part of summer. Our notes show that all complaints of this insect were received in the month of September.

In a report from Duluth, of injury by the above insect, we found the leaf-roller, *Archips paralella* partially responsible; at least that *insect* was reared from material sent.

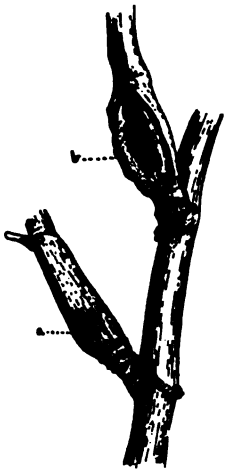
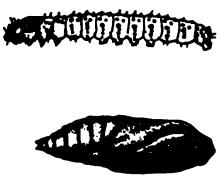


Fig. 56. Work of Box Elder Twig-borer. Original.

Where trees are not too large, spraying with arsenate of lead, four or five pounds in a hundred gallons of water, should be an easy means of controlling this pest. In cases of large trees, bamboo extensions handled from elevated platforms would enable one to place the spray higher than when working from the ground; or one could, in an emergency, climb quite a distance up large trees with stout branches, carrying the bamboo extension.

The Box Elder Twig Borer, is perhaps not, at this writing, a very serious pest, yet it is becoming extremely abundant. Our illustration gives a good idea of the appearance of the different stages of the insect, as well as the injury to box elders. The moth was identified for us, by W. D. Kearfott, as *Proteopteryx willingana,* described by him as a new species in 1904 (Canadian Ent., Vol. XXXVI, p. 306).

The collecting and burning of infested twigs in June and July would be a desirable way of lessening their numbers. This insect was discussed in the Twelfth Annual Report of the Minnesota State Entomologist, p. 97. At that time we had reared no males; and, from the females sent him, Dr. C. H. Fernald regarded it as *Proteoteras aesculanum* Riley. Specimens of males, however, were necessary to establish the exact identity of the insect.



Figs. 57 and 58. Larva and pupa of Box Elder Twig-borer. Original.

Fig. 59. Imago of Box Elder Twig-borer. Original

The Larch Saw Fly, *Lygaeonematus ericksonii* Hart, is an enemy of our tamaracks which has caused considerable alarm amongst Minnesota lumbermen. We assigned the problem in its general and special aspects to Prof. Ruggles, of this division, who reports upon his 1909 and 1910 observations as follows:

The northern part of Minnesota has an enormous acreage in timber, and will have for a number of years to come, in spite of the forest fires and normal cutting processes. It has been impossible to determine the amount of tamarack in this region, although a number of foresters familiar with the tamarack areas have been questioned. An estimate given ran up into the millions of dollars.

When the Larch Sawfly began its depredations, in 1908, there was great concern among the lumbermen. The presence of this insect was first noted in August, 1909; though, from the dead and dying tamaracks seen, the pest must have been at work during the two or three preceeding years. At the present time there are, to my knowledge, three areas of infestation in Minnesota—one at Itasca Park (a thirty-five-square-mile tract around Lake Itasca); one at Cloquet, where the State Forestry Experiment Station is located; and another near Ely, in the U. S. Government reserve. Unfortunately the writer has examined personally only the area at Itasca Park, and there not in the breeding season; but in each of two years, just as the larvae were leaving, or had, for the most part, left the trees.

Fig. 60. Work of Larch Saw Fly. Ruggles.

The work on the insect has been done almost entirely in the insectary. Several hundred cocoons were gathered in the spring of 1910, but from this number only 125 adults were reared; and of these it is interesting to note that three were males, a larger percentage than Dr. Hewitt found in his work on the Larch Saw-fly in Europe; although perhaps, with a larger number reared, a smaller proportion of males might have appeared.

One species of *Hymenopterous* parasite was reared, which occured in large numbers. I estimated that ten to fifteen per cent of the cocoons showed the presence of this parasite. Mr. C. T. Brues identified it as *Diglochus* sp.

Prof. R. H. Pettit, of East Lansing, Mich., learning that work was being done on this sawfly, kindly sent me a fungus preparation to scatter among the larvae as they were descending the trees to enter the soil. Unfortunately, this fungus arrived after the cocoons were well formed; but in spite of this a few experiments were started, and by September 1st the fungus had spread considerably. This fungus, however, seems to be almost identical with the one found by me this summer under natural conditions. In one small area I found as many as five per cent of the 1909 cocoons infested.

The season of 1910, in Minnesota, was the dryest in the history of the white man. In Itasca Park where, in former years, the mosquitoes had been unbearable, in 1910 no mosquitoes were present, even in the usually swampy regions of the Park. I give this to show how dry it was. Now, whether because of this excessive dryness or not, the larch saw-fly larvae did not remain on the tamaracks as long as they had in previous years, leaving while the trees still showed green. Also, the cocoons were considerably smaller than they had been in previous years. It seems, then, that the tamaracks here will have a little respite next year from the gross attacks of these pests. The other regions of infestation, according to reports received, did not manifest any such peculiarity.

Fig. 61. Larva of Larch Saw Fly. Ruggles.

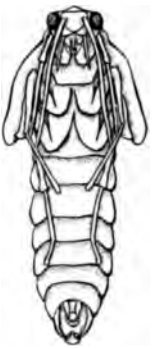


Fig. 62. Pupa of Larch Saw Fly. Ruggles.

Fig. 63. Cocoon of Larch Saw Fly. Ruggles.

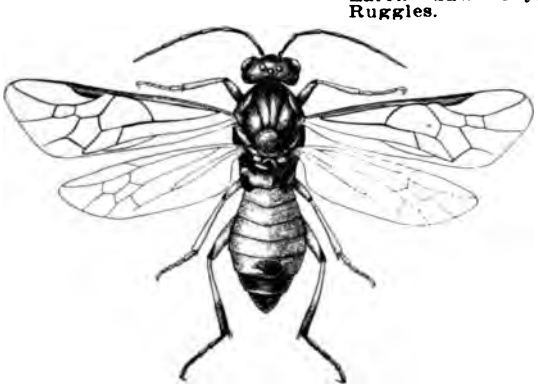


Fig. 64. Adult Male Saw Fly. Original.

The larva of this sawfly is, when full grown, a pale green worm, a little more than a half inch in length, and feeds upon the needles of the tamarack. The fly, or perfect insect, is half an inch long, with blackish body, marked by a band of red across the middle of the abdomen. It has four wings. This is the insect so well known for several years in the forests of the Middle West and New England. It is parasitized to some extent, and it is possible that we

will have to depend upon these parasites, or upon fungous diseas
in remote regions where large tracts are involved. They are n
always troublesome, doubtless owing to the work of the two age
cies just mentioned. If one has a few ornamental larch trees a
fected, the worms can easily be shaken off the tree; they will n
climb up the trunk. Or the trees can be sprayed with arsenate
lead, four pounds to 100 gallons of water. This Division w
probably have occasion to report further upon this timber pest
a later date.

A Cerambycid Beetle Infesting Black and Bur-Oaks.

On July 3d Dr. Franklin examined some bur-oak trees in Harriet Park, Minneapolis. Two large trees were in a dying condition, and two other very good specimens were already dead. In a borer-hole in the bark of one of these a beetle was found, which was pinned, and may be found by referring to accession reference, experiment 561. This was determined to be the Rustic Borer, *Xylotrechus colonus*. The presence of this beetle would seem to indicate that this was the species which caused the death and the dying condition of these trees. Several larvae were collected and bottled (see accession reference for experiment 561). Later, a large number of black oak trees in Minnehaha Park were found to be in a dying condition, and removal of the bark showed the work of a borer, which appeared exactly like that under the bark of the bur-oak trees in Harriet Park, above mentioned. So, while it is not certain, it seems probable that the Rustic Borer may have caused all this trouble.

It should be noted here that in other portions of Minneapolis, and also in St. Paul, oaks were seen during the season to be in poor condition, and a large number of them to be infested with borers. Whether many of them were infested with this insect is a question.

THE FRANKLIN CABINET FOR ALCOHOLIC MATERIALS.

As material preserved in alcohol or other liquid is often destroyed, or becomes much deteriorated by the liquids evaporating, it is desirable that vials containing materials so preserved should be kept in a place wherein the humidity is continuously at saturation point. When vials are left out, as they usually are, each having

Fig. 65. The case closed.

no particular place, they usually become dusty, and are difficult to keep in order. In view of these facts the cabinet described below was originated for the purpose of keeping alcoholic material clean,

in order and in condition. Details of this cabinet were designed by Dr. H. J. Franklin, hence we have given it his name.

The cabinet should be of galvanized iron. It has an inner and an outer door, with an air space between the two. The basal portion of the cabinet forms a pan or tray, which is air tight and contains a quantity of the same liquid as that which is in the vials. The cabinet contains a number of galvanized iron trays, open at the top. These are divided crossways into spaces of different widths, according to the lengths of the vials to be placed in them. A small glass tube, exterior to the bottom of the case, acts as an indicator to show, without opening the case, how much liquid the cabinet

Fig. 66. Case with outer door removed.

contains. This glass tube is provided with a stout wire guard. Our case, with the exception of the shelves, was made of tin throughout; and the bottom of it, where the liquid was kept, rusted badly in time. If it had been made of galvanized iron, this would have been prevented. Our case was made according to the following measurements:

The case proper is 28½ inches from top to bottom, 20 inches from front to back, and 18¾ inches wide. It rests on five tin feet. The inner door consists of a plate of tin, around the margin of which, on the inside, there rests a V-shaped ridge, which fits into a gutter of the same form. The gutter is lined with heavy felt. On the outside of this inner door there occur at regular intervals nine tin buffers, ranged in three rows. These buffers are in the form of truncated cones, the bases of the cones constituting the outer portions of the buffers. The outer door is one and one-half inches

Fig. 67. The case with both doors removed to show trays for holding vials.

from the inner one. It has upon its internal margin a square ridge, which fits into a square gutter exterior to the wall of the case. This gutter is also lined with heavy felt. The outer door is fastened in place by six clasps—one at the top and bottom, and two at each side. They clasp around the base of the outer gutter. This outer door presses snugly against the buffers on the outside of the inner door; *so that, when* the outer door is firmly clasped in place, the inner

door is kept also in place by the pressing of the outer door against these buffers.

There are seven trays, each of which slides, after the manner of a drawer, on a small tin shelf on each side of the interior of the cabinet. The shelves are 1½ inches wide. The tubular indicator is 3 inches long, and consists of a bent glass tube, the top of which enters the case just below the shelf of the lowermost drawer, and the bottom of which enters flush with the bottom of the reservoir for liquid. The connections for the indicator are made with plaster of Paris. The wires of the protecting screen are soldered to the side of the case. The drawers are 16¾ inches wide, 18 inches from front to rear, and 1 inch deep. The apartments vary in width ac-

Fig. 68. Details of trays of Franklin vial case.

cording to the lengths of the vials to be placed in them. Down the center of each drawer, running from front to back, on top, is a horizontal strip of galvanized iron, which holds in place the top of each partition. This strip is 1½ inches wide. The seven drawers are lettered in front from A to G, and the numbers on the partitions of each drawer run along the horizontal strip which runs across them above. This numbering and lettering is for the purpose of making it possible to "accession" the material and keep it in known order.

METHOD OF REARING BORERS.

As it became desirable to rear borers from white birch, a means was devised for doing so by Dr. Franklin, at that time in charge of the Insectary; and it proved so satisfactory that it seems worth while to describe it. This method has served not only the purpose of rearing these borers, to find out what they are, but it has proved to be so effective that it has value in rearing all borers when present in large numbers; and probably, by means of this method, a practically complete emergence can be obtained, thus giving a good idea of the amount of infestation in all cases in which this method is used.

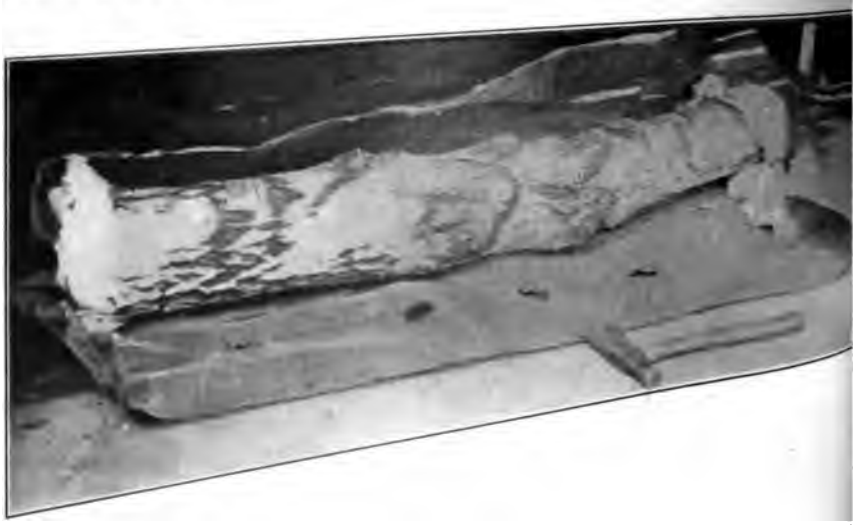


Fig. 69. A device for rearing borers from a log of considerable size. Inclosing the log. Franklin.

A portion of a cut-leaf birch log, badly infested with larvae of the Bronze Birch Borer, *Agrilus anxius*, seven and one-half inches in diameter at one end, and six inches at the other, and four feet two and one-half inches long, was carefully and loosely wrapped

in copper wire cloth, No. 60 mesh, so that only very minute insects could get through it. Along one side of the wire cloth were cut five small openings, the edges of which were deeply jagged. The individual scallops or jags in each opening were turned backward over a ring of cork, of such size that it would fit tightly into the base of a lamp-chimney; then this jointure or junction was reinforced with putty, which was tied in place with cloth bands until it got hardened. The outer ends of the lamp-chimneys, which made this close connection with the interior of the wire cloth case, were closed with removable tin box caps. The wire cloth was nailed down to the log, along one side and at the ends, with small staples; and the connection between the two ends of the cloth, so caught

Fig. 70. A four-foot two-inch log covered with wire gauze and chimneys in place. Franklin.

together along the side of the log, was made tight with putty. Small pieces of cork were nailed to the side of the log underneath this putty line, so that beetles which might emerge would have free chance to move all over the log, excepting around the ends, where they were shut off by cotton stuffed inside of the cloth and around the ends of the log. After everything was made tight in this way —the lamp-chimneys being in place, and their ends being held up from the ground in a horizontal position by cross-sticks placed under them—the whole cage was covered with coarse sacking and paper, and then this sacking and paper was covered with sand, leaving only the lamp-chimneys protruding. In this location the

log was provided with the natural dampness of the earth to a large degree, and at the same time the sand gave admission to enough air, so that everything was kept in good condition through the winter. This apparatus was kept in the outer cold portion of the insectary.

It will be seen that this cage was intended to work on the same principle as the parasite-cages already so generally in use—that is, the lamp-chimneys take the place of the glass tubes in the parasite-cage—and it was taken for granted that the beetles, when they emerged, would go to the light in the lamp-chimneys.

Fig. 71. The "borer cage" ready to be covered with sand. **Franklin.**

The log passed the winter in good condition, and the adult beetles emerged regularly from July 1st to July 8th, and were all in splendid condition, twenty-six in all being taken from the chimneys. The log was afterward chopped open, and no dead larvae or pupae were found in the experiment. The adults which were taken from the experiment were all pinned, and many larvae of this species were bottled, and these specimens may be found by looking up the accession references of experiment 410, 1908.

A general view drawing of this apparatus was made as it lay in working condition in the sand, and also a drawing of one of the lamp-chimneys, showing the connection between the lamp-chimney

and the wire cloth. Five photographs were made of this apparatus —one showing the apparatus in working condition in the ground; one with the dirt removed, showing the apparatus in place, with the wire cloth covered with paper and burlap; and one the same as the second with the paper and burlap removed, showing just the wire cloth enclosing the log, which, in the photo, shows through the wire cloth, and the lamp-chimneys in place; one showing the connections between a lamp-chimney and the wire cloth, the outer portion of the chimney having been broken off; and the fifth showing the interior view of the wire cloth, it having been detached from the log and opened out, showing the log lying inside of the wire cloth, with the cotton lying round its ends.

Fig. 72. Covered with sand in cold room of insectary. Franklin.

"MINNESOTA INSECT LIFE."

This publication, edited by the State Entomologist, is issued upon the first of April, May, June, July and August of each year. Its object is to place before farmers, nurserymen, fruit-growers, gardeners and housekeepers, timely items, which will be of value in suggesting methods of preserving their property from the attacks of insects. The first issue was June 1st, 1910, and hence there were but three numbers in that year. Next year (1911) there will be five numbers, beginning April 1st.

The name and address of any citizen of Minnesota, wishing copies of Minnesota Insect Life, will, upon request made to the State Entomologist, be placed upon our mailing-list, and copies will be mailed free of charge as soon as published. The contents of the 1910 issues, listed below, will give an idea of the nature and scope of the publication; which, by the way, is in no sense a bulletin, but merely intended to get certain facts before the public quickly, when most needed.

JUNE: Cutworms, Striped Cucumber Beetle and True Squash Bug; Oyster-shell Scale and Scurfy and Scale; House Fly; Strawberry Weevil; Spraying Compounds and Spraying; Green Cabbage Worm; Grasshoppers; Bee Pasturage; Stalk Borers in Flower-Gardens; Plant-Lice or Aphids; Item of Interest.

JULY: More about Grasshoppers; On the Successful Raising of Asters; The White Grub in Lawns; Mites and Lice of Chickens; Tent and Forest Caterpillars; The Cabbage Maggot; Jiggers; Items of Interest.

AUGUST: The Grasshopper Situation; The Army Worm; Black Flies and Mosquitoes; Ants in House and Garden; Spraying and Spraying Machinery; Cockroaches; The House or Typhoid *Fly.*

THE MINNESOTA INSECT CHARTS.

The Legislature of 1908 provided a fund of $3,500 for the preparation and distribution of a colored chart to the public schools of this state, under the direction of the State Entomologist. These were completed and distributed in the spring and summer of 1910; requests for them still reaching us. The chart is upon heavy, glazed paper, about 2 feet 10½ inches by 3 feet 9 inches, mounted with metal rods above and below, and contains about sixty-four colored figures, illustrating in natural colors many of our common (and some uncommon) insects, a few useful birds, and some beneficial insects. Drawings were made either from museum or from living specimens, by Miss Wood, artist of the Division, who also did all the color-work. The engravers and printers have attained fine results, remarkably true to copy, and the finished chart is an excellent example of what can be done with good brush work, the four-color process, and accurate and careful process work. The charts are fine enough to have called forth expressions of admiration and congratulations, not only from teachers and others in Minnesota, but also from many sources throughout the United States, the engraving company having sent samples of this work to many state institutions.

Following the suggestion of Prof. Schulz, State Superintendent of Public Instruction, letters were sent to all county superintendents, requesting them to advise us as to how many charts were needed in their counties. The required numbers were then sent by express, and were distributed by the superintendents, many of whom gave explicit instructions to their teachers as to the proper care and use of the chart. The following short circular, published by Prof. Frederickson, and sent with the charts to his teachers, is well worth being made use of in other counties:

Rules for Keeping and Using the Insect Charts.

This insect Chart is the property of the school district. It should be well taken care of. When not in use it should be rolled up so the dust and light will not dim the colors. I will suggest that a piece of oil-cloth, a little longer than the width of the Chart and about ten inches wide, be hung back of the Chart, so that when it is rolled up the oil-cloth can be wrapped around it.

The purpose of this Chart is to serve as a basis for teaching the pupils what insects are injurious to field and garden, and what can be done to exterminate them or lessen their number. Will suggest to the teachers that the study of one insect be taken up at a time, and give its life-history, its habits, what plants it feeds on and what may be done to destroy it.

Teach the pupils what birds are beneficial and should not be destroyed. Lessons of this kind could be given once or twice a week.

It is hoped the teachers will not regard this Chart simply as a curiosity, but use it as it was intended.

W. D. FREDERICKSON,
Co. Supt. of Schools.

The accompanying half-tone gives an approximately correct idea of the appearance of this chart, barring the lack of color. In addition to the brief description under each figure, we mail a pamphlet with additional information.

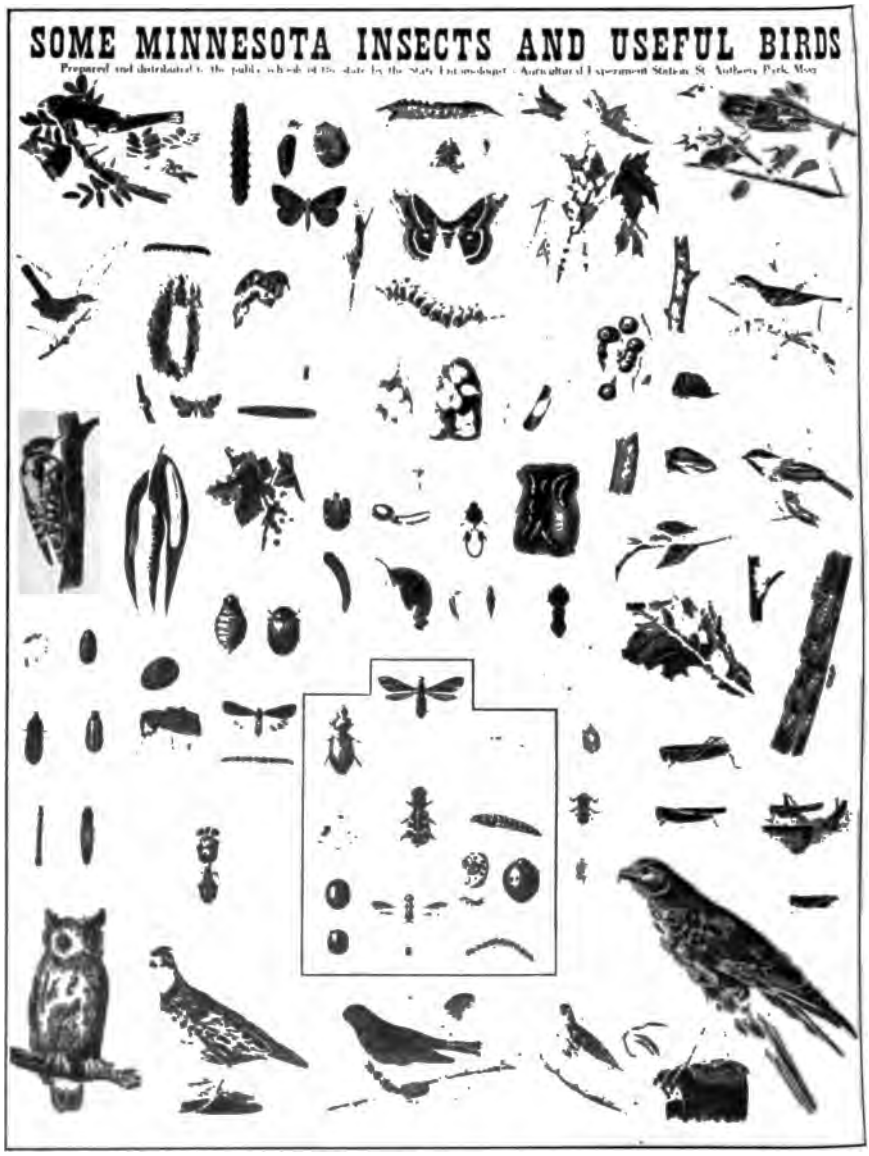


Fig. 725. *The insect chart distributed to the public schools of the State.* Much reduced.

NOTES ON WORK OF INSECTARY AND EXPERIMENTAL GARDEN.

In 1909 three hundred and fourteen different experiments were carried on in the insectary. Two hundred and fourteen insectary experiments is the record for 1910, which really represent a much larger number, included as "sub-experiments." A large number of insects, sent in to us for identification, were reared to maturity, as well as much parasitic material.

Fig. 73. A simple device used as breeding cage. Urbahns.

A parasite breeding-cage, built by Mr. Urbahns, and found quite satisfactory, is shown in Fig. 77. Cheese-cloth forms the upper half of the back and entire end of each set of cages, the partitions between the *individual* cages being of board. The front, as

indicated, is made of panes of glass, which slip into grooves, strips of felt making these glass doors (for such they are) tight. Fig. 73 shows a practical form of breeding-cage, also made use of by Mr. Urbahns; namely, large flower-pots under which any host material, other than a growing plant, can be placed. Upon the inverted flower-pots are placed glass chimneys, as indicated, into which ascend insects emerging and seeking the light. A board base, containing ventilators covered with fine copper gauze, may be used where collections of green materials are inserted.

In the experimental garden much work was done, in 1909, against stalk-borers, see page 85, and in both 1909 and 1910, various vegetables were planted for experimentation. The garden contained, in 1910, peas, beets, carrots, tomatoes, tobacco, corn, potatoes, cucumbers, clover, alfalfa, wheat, melons, sorghum, flax, beans, plum and apple trees.

The object of this garden was:

1. To have all these plants on hand as they were needed for insects in experimental work.

2. To carry on preliminary experiments in combating insects attacking these different crops.

3. To keep in touch with the different pests attacking each crop.

Sorghum was planted for the sole purpose of trying to see if *Contarinia sorghicola* would attack the seed. Melons were planted to watch *Aphis gossippi*, with hopes of getting notes on egg-laying habits. On potatoes, notes were taken on preliminary sprayings.

A few experiments were tried with insecticides, notably against the potato beetle, with both Paris green and arsenate of lead. This work was carried on by Mr. Stafford. We are hardly justified in forming absolute conclusions from the following results:

1. **Potatoes sprayed with arsenate of lead, 1 pound to 50 gallons. Results: Considerable reduction in number of larvae.**
2. **Potatoes sprayed with arsenate of lead, 2 pounds to 50 gallons. Very few living larvae present.**
3. **Potatoes sprayed with arsenate of lead, 4 pounds to 50 gallons. Results: About the same as in two preceding experiments.**
4. **Potatoes sprayed with Paris green, 1 pound to 50 gallons. Results: "But little improvement. Many living larvae."**
5. ***Potatoes* sprayed with Paris green, 2 pounds to 50 gallons. Very few *potato* beetles alive.**

6. **Potatoes sprayed with Paris green, 3 pounds to 50 gallons. Same results as No. 5.**

7. **Potatoes sprayed when dry with Paris green 1 ounce, flour 20 ounces. Killed the beetles and larvae.**

Comparative experiments were carried on also, by Mr. Urbahns, with arsenate of lead and Paris green. Good results were secured with arsenate of lead, 3 pounds to 25 gallons of water; and also with Paris green, 1 pound to 25 gallons of water. The comparative results were slightly in favor of the Paris green spray.

A poisoned bran-mash was used with success against cutworms. To two pecks of dry bran, enough Parish green was added to impart a *decidedly green color* to the mass. Then enough water was added to make it of the consistency of chicken dough. Then enough black molasses was added to sweeten it and give it a decided odor. Any syrup might have done as well, possibly. This poisoned dough was scattered about in small masses amongst the plants in the experimental garden.

Preliminary Work with White Grubs.

Lachnosterna adults, removed from sod in insectary, garden on May 29th, and placed in a breeding-cage under out-of-door temperatures, were first active on April 11th. Fed freely on plum-leaves. Three hundred and fifty of these adults were placed in cages containing soil. They were active on warm nights between April 11th and June 1st. Thirty adults of *Lachnosterna*, remaining alive on June 1st, produced 106 eggs. See Fig. 73½.

Fig. 73½. Eggs of White Grub Beetle *Lachnosterna*. Urbahns.

May 5th, thirty adults captured in a lantern trap—most of them died. Thirty-five eggs had been deposited in the soil June 1st. These came from those of the captured beetles which survived after being placed in breeding-cage.

June 10, twenty-six adults taken in lantern-trap during night. Some of these were observed mating.

June 11, fifty-three adults taken in lantern-trap. These deposited a few eggs.

A Successful Method of Securing the Fertilization of Clover by Means of Bumble Bees, in Experiments with Bruchophagus funebris.

At the very beginning of work on the life-history of *Bruchophagus,* we found it necessary to secure clover-seed properly fertilized, and yet immune from insect attack. This, as we discovered, was a most difficult thing to accomplish. For two years we tried in vain to do this by hand-pollination, the work being begun by Mr. Ruggles and continued by Dr. Franklin. Naturally we were discouraged. I am happy to say, however, that this year, by the method described here, we have succeeded in this very essential principle, and have had no trouble in securing fertilized seed, suffering in no way from insect attack, and thus forming a basis for investigations on the life-history of the insect in question. As stated above, the work was begun over two years ago by Mr. Ruggles, later joined by Dr. Franklin. We have recently added to our force, under the provisions of the Adams Act, Mr. Theodore Urbahns, who at present giving his entire time to this problem. Mr. Urbahns invented a simple cage, which seems to answer the purpose *which it* was intended excellently well. This cage is made w

Fig. 74. A mica lamp chimney sh ing method of inclosing cloverh Urbahns.

a wooden frame, covered with white cheese-cloth on three sides and on the top. A loose glass plate forms the fourth side. The floor is of wood, perforated in the center in such a way as to allow cloverheads from two or more plants to be introduced into the cage. The apparatus is suspended over the growing plants. The perforations through which the clover-heads are introduced can be shut to exclude other insects, and to keep the clover-stems in place, by means of two wooden shutters.

Fig. 75. A simple and successful breeding cage. Urbahns.

The method of procedure in securing the cross-pollination of the florets has been to confine the green heads in other cages, made of mica lamp-chimneys, closed at the top with a piece of cheese-cloth and at the bottom with a fold of the same kind of cloth, which can be firmly tied around the stem bearing the introduced head. This cage is held in place above a plant by a cord from above and below. The latter apparatus was suggested in an article by C. E. Hood in the April, 1909, number of the Journal of Economic Entomology. Of course these heads might have been covered with cheese-cloth bags, but in that case they could not have been so easily watched. When the florets open and are ready for pollination, they are removed from the mica cages and introduced into the cage made by Mr. Urbahns, and described above. Into this cage one or two bumblebees are introduced, and we found that early in the season the bees worked faithfully every day, after becoming accustomed to their prison, occasionally for as long as three weeks. Later in the season their work was not quite so satisfactory, but when captured early in the morning they usually worked well for a few hours, after which time they were liberated. When these clover-blossoms have been thoroughly gone over by the bees, they are removd from the cage, and again placed in the mica cages for future

[illegible] used with Bumble Bees.

[illegible] the white lines [illegible] the imprisoned insect [illegible] glass

[illegible]

A Jumping Seed-gall on Oak Trees.

Mr. C. N. Ruedlinger, Forester of the Minneapolis Parks, brought in on July 3d, 1909, some leaves of bur-oak, which bore on their undersides large numbers of little round galls. These galls contained the larvae of small insect, apparently Cynipid or Chalcid, and a rustling sound could be heard across an ordinary-sized room because of the movement of the larvae inside the galls. Mr. Ruedlinger also brought a large number of the galls which he had collected from the ground, these having become detached from the leaves of the trees and fallen down in large numbers. In their detached condition the insects had the power of making the galls which surrounded them hop several inches from one place to another. When on the trees, there occurred from a few to several hundred of these galls on a single leaf. They seldom were found toward the basal portions of the blade of the leaf, but were scattered over the rest of the leaf. These "jumping seeds" as the public called them, excited much interest.

Corresponding with the positions of the galls on the lower side of the leaves, there were convexities on the upper surface. These galls, while round, were flattened somewhat, that is, depressed.

Some of the galls were opened at the time they were brought in, and the insects inside were found to be in the pupal stage. When the galls reached the stage at which they detached themselves from the leaves they were a very light chrome yellow color, and about 2 mm. in diameter. These were placed in lamp-chimneys, the ends of which were covered with muslin, and were placed on the ground both inside and outside of the insectary. In this way they could be kept and given the natural moisture of the earth. The galls continued to show their hopping movements with considerable vigor as late as August 4th, and a slight hopping was noticeable as late as August 21st.

A large number of insects, mostly Chalcids, emerged in these experiments from July 1st to August 2d. These were apparently parasites on the real gall-formers, as but a small percentage of the galls show that insects had emerged from them, and the hopping continued for a considerable number of days after these insects ceased to emerge.

These parasites were all mounted in balsam on slides, and some of the leaves bearing the galls were pressed and put up in Riker Mounts, and a large number of the galls were bottled in alcohol and formalin.

On September 17th these insects were all placed under a cage out of doors to be carried through the winter, but no a have emerged up to the date (Dec. 1, 1910) of making this re From descriptions, however, of the gall of *Neuroterus saltat* and a careful examination of this gall we believe that to be species in question.

Fig. 78. Jumping Seed Galls. Upper and lower views of leaf and details. O

Work with the Box Elder Borer.

Moths of this insect were sent to Prof. Fernald for determination some time during the summer of 1908. Prof. Fernald was unable at that time to give a definite determination because he lacked the males, that sex possessing the more distinctive characters. From the females sent him, he judged it to be *Protcoteras esculanum*, Riley.

After this further experiments were carried on to get more insects for determination, and to learn more about the life-history of the insect. First an experiment was conducted to secure the egg-laying of the moths and find out the length of larval life. Adults were placed in a breeding cage on box-elder seedlings. Some time after the moths had disappeared this experiment was examined, and large numbers of small larvae were found feeding next to the midribs of the leaves of the tree, and some were crawling up and down the stem of the plant. These larvae finally, after feeding on the leaves for a considerable length of time, as cooler weather came on during the latter part of August, stopped feeding on the leaves, which they had at this time pretty well skeletonized, and bored into the tips of the twigs. They remained in this position for some months, but the plant finally died and the insects also perished. A few small larvae were saved and kept in small branches of box elder, which were kept moist all winter, but these, too, finally died, so that a complete cycle of the life-history was not obtained, but it is evident that the small larvae pass the winter in twigs of box elder, and in the spring proceed with their development until they become full grown.

On June 23d and again on July 14th, a large number of these borers were collected from box elder, for rearing to get the moths. By July 14th a large part of the borers gathered on June 23d had pupated, and from this time on the remaining larvae went into the pupal stage rapidly. On July 14th the first moth in captivity emerged. The last moth of which we have record, emerged on

August 4th. Nineteen moths in all were reared. With this material at his disposal.

There is bottled material showing the work of this insect, and for that matter branches showing its work could at any time be collected. At all events, if this insect is written up, it would be desirable to have a photograph showing its work. Some of the borers were bottled, and some were also inflated. All the pinned and bottled material connected with this borer may be found by referring to accession references of experiments 544, 588 and 590. In experiments 588 and 590 parasites emerged and were pinned.

Mr. W. D. Kearfott identified this insect as *Proteopteryx willingana,* which is described by him in the Canadian Entomologist Vol. XXXVI, page 306. The late Dr. Fletcher refers to it (Report of 1904) as "The Negundo Twig Borer," and states that it has become quite a pest in Canada to trees of that genus, though not a serious one. It occupies about the same position in Minnesota. Manifestly the burning of infested twigs which contained insects would afford relief during the latter part of June and during July would be a desirable way to lessen their numbers.

THE TYPHOID FLY ON THE MINNESOTA IRON RANGE.

Your entomologist was called upon in September, 1910, by a member of the State Board of Health, to visit with him some of the towns of the Iron Range, for the purpose of determining to what an extent the house fly or typhoid fly was responsible for an epidemic of typhoid fever then prevalent there.

During the first trip, and on the occasion of a second trip made later, we found the following conditions: House flies were extremely abundant, and houses of miners, boarding houses, cheap hotels, camps, etc., were improperly screened. The surroundings of some of the dairies in that section were in the highest degree unsanitary. Revolting conditions, in large part the result of ignorance or indifference, or both, on the part of the miners, were prevalent in every place visited. The miners consist largely of Austrians, Italians, Finns, and a very few Swedes. Although the Finns and Swedes are by far more cleanly in habits and environment than the other two races, they were the chief sufferers from typhoid, due to the fact, we believe, that both Finns and Swedes lunch frequently during the day upon cold food. The Italians eat hot meals, as do also the Austrians, and the former use but little milk. These two races, although much to be criticised along the lines of cleanliness, escaped typhoid. The cold food referred to above is on the table all day, freely visited and walked over by flies which enter through unscreened windows or doors, having come directly from near-by filth; in some cases undoubtedly from typhoid excreta deposited in open vaults without having been sterilized. In more than one case we found a landlady temporarily caring for a typhoid boarder before he went to one of the hospitals, if indeed he were fortunate enough to get into a hospital, and at the same time cooking for her remaining guests. A dangerous combination, especially with the prevailing ignorance as regards the germs of the disease.

We found that the sewer of one of the towns, a city of about 12,000 inhabitants, *emptied into* an open creek less than a mile away,

Fig. 80. Alley near Main street of one of the Range towns.

and that flies of various kinds congregated there upon the filth floating in the slow-moving stream. Delivery wagons cross this creek in their trips to and from neighboring towns and "locations" many times a day, and we personally observed that flies were carried from the creek upon vehicles of this sort, offering, with the unscreened houses everywhere met with, ideal conditions for the spread of the epidemic. To add to the difficulties which local au-

Fig. 81. Another filthy alley.

thorities have to contend with is the fact that Finns, Austrians, and Italians are more or less fatalistic in their views, and furthermore, they are somewhat suspicious of would-be well-doers connected with the mining companies or cities; they are loath to use the medicine given them (especially true of the Swedes), and evidently have not been used to such attention in the old country. It

must be borne in mind, also, that these foreigners have brought with them from their own countries all their habits; their temperament is unchanged; they surround themselves here with the same conditions, as far as they can, which they found congenial there—all of these facts make it difficult for the authorities to cope with infectious diseases.

In addition to more modern methods of disposing of sewage, there is evidently need of constant, intelligent supervision over these people on the part of conscientious experts. Why more of them do

Fig. 83. Creek into which the sewage of a large town enters.

not die of typhoid is a wonder. The same kindly Providence which keeps an intoxicated man from harm must be caring for them in their blind ignorance. We left the locality impressed with the existence of the following significant factors: Exposed foulness of all kinds, including pathological excreta, in close proximity to *human food*; an enormous number of flies congregating in towns

and settlements where an abundance of moisture and filth were found; absence of screens on windows and doors, and dense ignorance and indifference on the part of the miners. We could draw, from our visits, only one conclusion, that the typhoid fly was the agent for the spread of typhoid in that locality; as well as for the occurrence of a mild form of dysentery which appeared there in July and August. This dysentery appearing in mid-summer, at a time when the water supply was above suspicion, and differed from the water-caused dysentery (prevalent there in May, and directly traceable to the water supply), by being mild, causing but little pain and nausea, and but little or no fever. Patients lost but little time from work.

For the most part, health officials in the towns visited are doing all they can to better the conditions outlined above, and it must be borne in mind that the Iron Range is not the only locality where such conditions prevail. Outbreaks of this sort may and do occur wherever filthy conditions accompanied by ignorance and by house flies occur. We insert here a few illustrations emphasizing these conditions in the localities visited. It is encouraging, in this connection, to note the presence of splendid schools on the Iron Range, of night schools well patronized, and of a class of men who believe in the education and betterment of the conditions of the foreign population, for business reasons, even if not influenced by altruistic motives.

FIG. 84. A small table in a miners' boarding house. Food is exposed on these tables at all times.

ORCHARD AND GARDEN SPRAYING.

Introduction.

The following article on "Orchard and Garden Spraying" is the result of the collaboration of A. G. Ruggles of the Division of Entomology, and E. C. Stakman of the Division of Plant Pathology. Its appearance at this date is timely, and there is much demand for the information contained therein.

By the up-to-date orchardist spraying is considered as essential as any of the other processes necessary to the production of good fruit. It is regarded in much the same light that insurance is to the householder. Without spraying one runs the risk of considerable loss. To spray intelligently one should know just what he is spraying for, and it is nearly always essential that he should know at least the main features of the life history of the pest sprayed against, be it insect or disease. In the following pages we have endeavored to give brief life histories, and thus show the reason for spraying with such and such a compound in each case. Very often we can advantageously use a fungicide at the same time we use an insecticide. It is advisable to do this wherever possible. In fact, when spraying against a known insect, it is always good policy to combine even if not absolutely sure of the disease to be sprayed against. Sometimes, as with the lime-sulphur washes, a spray is both an insecticide and a fungicide. Arsenate of lead has a small fungicidal value, and when added to the lime-sulphur wash his fungicidal value is increased.

A few precautions are perhaps necessary, viz.:

1. Never spray when the trees are in bloom. A day's delay at this time will not materially affect the result of the spray. Bees and many other insects are very numerous at this time, fertilizing the flowers. A spraying compound thrown on them will lessen the amount of fruit set and destroy the honey bees.

2. Sprays recommended for the dormant season should never be tried when the trees are in leaf.

Before taking up the insecticides and fungicides in detail a general idea of the use of these killing-compounds may be desirable.

The "cide" of these words means "kill." An insecticide is something that will kill an insect; a fungicide is something that will kill a fungous disease. Different kinds of compounds are used for the different kinds of insects and diseases. There is no one spray that is the "cure-all" for everything. For instance, insects that bite, like caterpillars and beetles, take one kind of insecticide; insects that suck, like plant lice and scales, require another kind of insecticide. One fungicide is good for one disease, but it may be worthless against another disease. The insecticides are usually separated into three groups:

1. Gaseous insecticides. These are used in an enclosed space against either biting or sucking insects. Hydrocyanic acid-gas, carbon-bisulphid, and tobacco smoke come in this group.

2. Contact insecticides. These are used against insects that suck their nourishment from plants through a proboscis-like beak, or against biting insects that cannot be induced to eat the parts of the plant covered with an internal insecticide. In this group are found the lime-sulphur washes, crude petroleum, kerosene, soaps, miscible oils, etc.

3. Stomach or internal insecticides. These are used against insects that eat the foliage. The most important of these, like arsenate of lead, Paris green and arsenite of lime, contain arsenic in some form, and are called arsenical insecticides. The killing ingredient in these insecticides is not soluble in water, but is in the small particles of matter that remain in suspension in the liquid.

The fungous diseases of plants are caused by minute parasitic plants known as fungi. Fungi, having no green coloring matter (chlorophyll), are reduced to the necessity of getting their food from other plants or animals, or from the dead remains of plants or animals. These fungi are composed of a great many threads, which gain entrance to the tissues of the host plant, and absorb their nourishment from it. Minute reproductive bodies, known as spores, are produced. One fungus may produce more than one kind of spore; during the growing season it may produce one kind, which is especially well fitted to reproduce the plant very rapidly, while later in the season it may form another kind of spore which will live during the winter and germinate the next spring.

The cold-resisting spores may live during the winter in the soil, on the seed, on leaves, rotted fruit, or in rubbish. Further, the threads of the fungus may themselves live during the winter; they

may persist in the seeds, on mummied fruit, or, in the case of shrubs and trees, in the twigs. Each fungus has its own life story: it gets into the habit of going through its life cycle in a definite and fairly constant way. It may require, during the course of its complete development, two different kinds of plants. For instance, the rust of Wealthy apples is caused by a fungus which lives in red cedars in the winter and on apple trees in the summer. It is necessary, then, in order to effectually prevent fungous diseases, to know the life habits of the fungi causing them.

Preventive and curative measures are various. Spraying is resorted to when it is possible, by covering plant parts with some mixture either to kill superficial fungi like powdery mildews, or to prevent the spores from germinating properly and thus infecting the plant. If the fungus gets inside the twigs or branches, pruning must be resorted to, while if it lives on decayed or dried fruit, leaves or rubbish, these should be removed and burned. Seed disinfection is necessary in case the seeds are affected; such treatment is of value in preventing diseases like potato scab. Then, too, if the spores of the fungus persist in the soil, retaining their vitality for considerable periods, it is necessary to rotate crops or sterilize the soil. Again, it may be necessary, when a fungus requires two different plants for its complete development, to remove the so-called alternate host. Such a necessity often arises in dealing with apple rust; the removal of red cedars from the vicinity of the apple orchard prevents the rust from living through the winter. Some fungi gain entrance to their hosts mainly through wounds; obviously, in such cases, great care should be exercised in avoiding injuries, and in disinfecting and covering all wounds. Some varieties of fruit are more resistant to a certain disease than others; these should, naturally, be selected. Weather and soil conditions often affect to a remarkable degree the prevalence and severity of a disease; it is not always possible to control these factors, but some precautions can always be taken both in the greenhouse and in the field; the proper kind of soil can usually be selected, good ventilation can be provided for, and excessive shade can be avoided.

Fungicides may be applied in different ways: they are usually used as steeps or sprays, sometimes as washes. The subject of sprays is still somewhat problematic. Bordeaux has been regarded as a "cure-all," but, under certain circumstances, it is objectionable. It stains the plant parts with which it comes in contact, so is unfitted for use on ornamental plants or ripening fruit. Further, the

copper salts which are formed have an injurious effect on certain plants, among them the plum. In such cases, it is necessary to employ some other fungicide, or, at any rate, to use very weak bordeaux. Nevertheless, bordeaux, although being replaced to a certain extent by some newer fungicides—notably the self-boiled, lime-sulphur mixture, is probably better, for general purposes, than any other. The proper strength of bordeaux is still somewhat uncertain; in fact it varies with conditions. The 5-5-50 formula has been regarded as standard, but excellent results have been obtained with weaker solutions, so it is probable that, for general work, a 4-4-50 mixture will be sufficiently strong.

The following are the fungicides in common use as sprays: bordeaux mixture, lime-sulphur wash, self-boiled lime sulphur, ammoniacal copper-carbonate, potassium sulphide. In addition to these, flowers of sulphur is often used, especially against powdery mildews, while corrosive sublimate and formalin are used in seed treatment.

The amount of spray to apply will vary with the size of the tree. A tree having a spread of twenty-five feet in full leaf will require at least four gallons. The person just learning to spray ordinarily does not put on a sufficient amount, but stops before even half of the required amount has been given. This is one of the main reasons why spraying is not as successful as it should be in the hands of the beginning orchardist. A man must also learn to apply the spray evenly and thoroughly, and, with possibly one exception, not in the form of drops, but in a very fine mist.

In our discussion of the plant pests, there are perhaps many forms that we have not mentioned. It may be that they have never been reported to us as being found in this state, or perhaps are only of local importance. The Divisions of Entomology and Plant Pathology of the Experiment Station are always willing and anxious to find out the various pests present in the state, and will welcome correspondence and specimens of diseased plants, or, in the case of insects, the enemies themselves.

INSECTICIDES AND FUNGICIDES.

Alphabetically Arranged.

AMMONIACAL COPPER CARBONATE. This is not as good for general purposes as bordeaux mixture. It is used instead of bordeaux when it is desirable to avoid the spotting of leaves or ripening fruit. It is prepared as follows: Weigh out the proper

amount (5 oz.) of copper carbonate and use just enough ammonia to dissolve it. If the ammonia is strong it should first be diluted with water. Then add the proper amount of water (50 gallons).

ARSENATE OF LEAD. Arsenate of lead is one of the most valued of the arsenical insecticides. It has in many cases entirely displaced Paris green with orchardists, and there are at least two good reasons for it.

First. The arsenate of lead has great adhesive qualities. It will not wash off even in quite heavy showers of rain. Some of our experiments here at the Station showed the presence of this arsenical on the leaf in sufficient quantity to kill insects ten weeks after spraying.

Second. It can be used in any strength without burning the foliage of the plant sprayed.

Third. It has some fungicidal properties that are increased when added to *Lime Sulphur.*

Arsenate of lead can be made at home or bought in paste form on the market. Ordinarily it will be easier to buy the prepared material.

The formula of the home-made is as follows:

Twenty-two ounces acetate of lead (sugar of lead) dissolved in 2 gallons of warm water in wooden pail.

Eight ounces arsenate of soda dissolved in one gallon warm water in another wooden pail.

These two solutions poured together make a sufficient quantity of poison for 50 gallons of spray.

Three pounds of the commercial paste are recommended for 50 gallons of spray.

ARSENITE OF LIME. This is essentially a home-made preparation. If made properly it is just as good as Paris green and is much cheaper. The best method of preparation is as follows:

White arsenic, one pound.

Crystal sal soda, four pounds.

Water, one gallon.

Boil these in an iron kettle for twenty minutes or until thoroughly dissolved. *The kettle must be kept exclusively for this purpose.* The soluble material obtained is arsenate of soda, and can be stored away in jugs or bottles, labeled "poison," for future use.

For 40 or 50 gallons of spray take 1½ to 2 pints of this solution and 4 pounds of freshly slaked lime. Dilute the lime and strain then add the quart of the stock solution. Pour into the spray barrel and it is ready for use.

BORDEAUX MIXTURE. This is made of copper sulfate (blue stone), quick-lime and water. It is used in various strengths, the 5-5-50 being probably that in most common use, although the 4-4-50 will probably give equally good results. 5-5-50 simply means that 5 pounds of copper sulfate, 5 pounds of lime and 50 gallons of water have been used in the preparation of the spray. In the same way 2-2-50 would mean that 2 pounds of copper sulfate, 2 pounds of lime and 50 gallons of water have been used. The number of pounds of copper sulfate is indicated by the first figure, the number of pounds of lime by the second, and the number of gallons of water by the third.

One of two methods may be used in making bordeaux. Either it may be made directly or stock solutions may be made and these stock solutions used whenever the fungicide is needed. In making the spray directly, take 5 pounds of copper sulfate, put it into a coarse gunny sack and hang it in a barrel containing 25 gallons of water. Being suspended, the copper sulfate will dissolve much more readily than if put into the bottom of the barrel. Now slake carefully 5 pounds of good, quick lime, using just enough water to slake it slowly. Be sure that the lime is not all air-slaked. When the lime is slaked, add enough water to make 25 gallons Now stir it carefully and then pour together the copper sulfate solution and the milk of lime. It is desirable to have a slight excess of lime, since it prevents any injurious action of the copper salts. If there is an excess of copper, foliage injury is liable to result. Therefore two simple tests should be made to determine whether or not the mixture is safe to use. Take a piece of newly-filed iron or steel and put it into the mixture for about a minute. If it has a copper coating when it is taken out there is an excess of copper, and more lime should be added. To determine whether or not there is a sufficient amount of lime in the mixture, pour some of it into a flat dish and blow on it for a few moments. If a film forms on the surface, enough lime is present, if not, more should be added. In making stock solutions, dissolve copper sulfate in water at the rate of 1 pound to 1 gallon of water. Slake the lime slowly in another receptacle and, when slaked, add water until a thick, lime milk, 1 pound to 1 gallon of water, is formed. When using the

tock solution in making up the spray mixture, 1 gallon of copper ulfate solution represents 1 pound of copper sulfate and 1 gallon f lime-water represents a like amount,—more or less, depending n the amount of water used in making the stock solution. The roper amount of stock solutions should be diluted separately before they are poured together. The stock solution of lime should e first run through a fine mesh sieve to remove all lumps which ight clog the nozzle of the sprayer.

CARBON BISULFIDE: This is a very inflammable liquid hat volatilizes readily when exposed to the air. It is one of the gaseous insecticides used against weevils, etc.

COPPER SULFATE WASH:

Copper sulfate, 3 pounds.

Water, 50 gallons.

This is used as a wash on dormant trees for prevention of such diseases as apple scab. It must never be used on trees after the buds have burst.

CORROSIVE SUBLIMATE:

Mercury bichloride (corrosive sublimate), 2 ounces.

Water, 15 gallons.

This is an extremely poisonous mixture and should be handled with great care. It is very effective against potato scab. It should not be made in tin vessels as it corrodes them.

CRUDE PETROLEUM: This is an oily, inflammable liquid hat when refined yields such products as paraffin, lubricating oil, erosene, etc. A petroleum having a specific gravity of 43 degrees (Baume scale), is an excellent insecticide for scale insects. In fact it was used very successfully against the San Jose Scale until he lime-sulfur wash was found to be better.

FORMALIN:

Formalin (40% formaldehyde), one-half pound.

Water, 15 gallons.

This is used in treating seed for prevention of such diseases as otato scab.

HELLEBORE: This is a stomach or internal insecticide. It is ot poisonous to man as are the arsenical insecticides, and therefore used where there is danger of poison remaining on parts to be ten. It is often used on currants and gooseberry bushes when e berries are beginning to ripen. This material can be used in e dry form, or as a spray at the rate of 2 or 3 ounces to a gallon.

HYDROCYANIC ACID GAS: This gas is made by dropping potassium cyanide into sulfuric acid and water. The fumes are deadly to all kinds of animal life, and the gas is used only in special cases. As this gas is fatal to human life as well as to insect life, it should be used only by an expert.

IRON SULFIDE MIXTURE: This is a comparatively new, but, according to Circular No. 58 of the Bureau of Plant Industry, U. S. Department of Agriculture, very promising fungicide. It was tried in particular on apples, and gave splendid results, both in preventing fungous diseases and in non-injurious effects on the fruit. In preparing this fungicide, it is recommended that a self-boiled, lime-sulfur mixture be prepared as previously described except that 10 pounds of lime and 10 pounds of sulfur are used. The mixture is diluted to 40 gallons and then 3 pounds of iron sulfate, (copperas) dissolved in about 8 gallons of water, is added.

KEROSENE: This is an excellent contact insecticide, the merest particle of it coming in contact with any part of the anatomy of an insect is fatal. Pure kerosene, however, will burn the leaves of plants, consequently it is only recommended to be used in the pure form when trees are dormant, or against insects off of plants, for instance, the killing of grasshoppers by hopperdozers, or household insects, etc.

KEROSENE EMULSION: This is probably the best form into which kerosene can be put for spraying growing plants. A stock emulsion is made as follows:

Hard laundry soap, shaved fine, ½ pound.

Water, 1 gallon.

Kerosene, 2 gallons.

Dissolve the soap in boiling water, remove from the stove and immediately add the kerosene; churn with a bucket pump until a soft, butter-like, clabbered mass is obtained. One part of this stock solution is added to ten or twelve of water for spraying. If the stock solution is properly made this can be used on tender foliage of plants for such insects as plant lice, etc.

LIME SULFUR: Within the last few years this wash has become very prominent. It is one of the best scale insecticides yet discovered, and will kill the eggs of plant lice. As an insecticide it has an accumulative action, being more active a few weeks after *spraying than* at the start. Since coming into prominence as a

ıle insecticide it has been found, quite recently, that in its several rms it is an excellent fungicide, and will, in many cases, replace ɔrdeaux mixture. There are several formulae for making this ash, three of which are appended.

The Boiled Mixture:

Best stone lime, 15 pounds (not over 5 % impurities).
Flowers of sulfur, 15 pounds.
Water, 50 gallons.

Slake the lime in a small quantity of hot water, add the sulfur radually and stir thoroughly. Dilute the mixture to 15 gallons ith water, and boil in an iron kettle, or cook by steam in a barrel ɔr forty-five minutes. Fill the vessel with water to the required ɔ gallons; strain the wash through a fine mesh strainer, and apply ɔt.

This wash should be applied in the fall after the leaves have ɔpped, or in the spring before the buds open. Spray thoroughly, ɔvering all parts of the tree.

CONCENTRATED LIME SULFUR: When stored away it is best ı cover the solution with a layer of oil about an eighth of an inch ıick. This will prevent evaporation, and the forming of a crust ı the material. The material should not be stored where the tem-ɛrature would go very low.

In spraying with this mixture definite dilution must be made, ıd to do this a Baume scale is required. The amount of dilution ill vary from one part of this concentrate in nine or ten parts of ater to one part concentrate in thirty or more parts of water. his concentrated material is now on the market in a commercial ɔrm, and is generally very reliable.

Formula:

80 Pounds sulfur.
40 Pounds best stone lime (95% calcium oxide).
50 Gallons of water.

The cost of making this material will depend on the amount ıat can be made at one time, and the cost of material and labor. he average cost is about $2 per barrel of 50 gallons. Usually it not practicable to make as much as 50 gallons at one time, conse-ıently the following directions are for making only 25 gallons. ive steam run in a barrel, or fire under an iron kettle may be used ı boiling.

Place five gallons of water and forty pounds of the sulfur in ıe vessel and apply heat until the sulfur becomes a smooth paste,

stirring constantly. Now add ten gallons of water and the twenty pounds of lime and boil for forty-five minutes. Add water to make the twenty-five gallons. When cooled to 65 degrees F. test with the Baume scale, the reading should be about 33 degrees.

As a scalecide to use in the dormant season this should be diluted 1-10 (i. e.) one part of the above formula diluted with nine parts of water, and 6-10 pounds of stone lime added to every fifty gallons of the spray.

As a fungicide for summer use dilute 1-30. (One part of stock formula diluted with twenty-nine parts of water.)

SELF BOILED LIME SULFUR:

Lime, 8 pounds.
Sulfur, 8 pounds.
Water, 50 gallons.

This spray is especially valuable in cases where bordeaux is injurious to foliage or fruit. The stone fruits, such as plums, are particularly susceptible to bordeaux injury, while some varieties of apples are badly russeted by it. There is slight danger of injury by the self boiled lime sulfur preparation and it is an efficient fungicide when properly made. It stains the fruit as does bordeaux. In making it, eight pounds of lime of good quality should be placed in a barrel, and enough water to nearly cover it should be added. While the lime is slaking, add sulfur which has been run through a sieve to break up the lumps. The sulfur should be thoroughly stirred into the slaking lime, enough water being added to make a pasty mass. The barrel should not be covered, in order to retain the heat, and the contents should be occasionally stirred. The time required varies with the quality of the lime; if the lime acts quickly, five to ten minutes will be sufficient, while if it acts slowly, fifteen minutes may be necessary. It should not be allowed to stand too long, because it may, in that case, be injurious to foliage. Now add a little water, stirring the mixture while it is being poured in. Then add enough water to bring the total up to 50 gallons. In applying the spray it is necessary to have a good agitator in the sprayer.

MISCIBLE OILS (Oils that will mix with water):

There are several oils on the market that are miscible with water. These make a good winter spray for scales, and are also excellent summer sprays against the same insects. Great care, how-

ever, must be taken to obtain the right dilution as per directions given on container, or burning of the leaves will result.

PARIS GREEN: This is the old stand-by, and is still used by many where an arsenical insecticide is necessary. Our experiments on orchard trees and other reports indicate that arsenate of lead is better in every respect, although our potato expert at the Experiment Station, Mr. Kohler, who has experimented with many of the stomach insecticides for potato beetles, finds Paris green the most satisfactory for these pests. It is generally used at the rate of 1 pound to 50 gallons of spray. In using always first make a paste of the Paris green and water, and then add to the spray material. If water alone is used, 2 to 3 pounds of stone-lime should be added. If Bordeaux mixture is used the addition of lime is not necessary.

POTASSIUM SULFIDE (Liver of Sulfur):

3-5 Ounces of potassium sulfide.

10 Gallons of water.

This is used in place of bordeaux to avoid spotting of foliage and fruit. It is considered to be especially effective against powdery mildews, such as the gooseberry mildew. It is also quite extensively used in greenhouses and on shrubbery.

PYRETHRUM OR INSECT POWDER: This is a powder from the ground up flowers of the pyrethrum plant. It is a contact insecticide and is used against fleas, cockroaches, etc. If the powder is burned in a room the fumes will destroy mosquitoes and flies.

THE RESIN-LIME MIXTURE: This is a mixture often used in combination with a fungicide or an insecticide to insure the sticking of the necessary poisonous material to smooth, glossy leaves.

Formula:

Pulverized resin, 5 pounds.
Concentrated lye, 1 pound.
Fish or other animal oil, 1 pint.
Water, 5 gallons.

Place the oil, the resin and one gallon of the water in an iron kettle, and heat until the resin softens, then add the lye and stir thoroughly. Add to this four gallons of hot water, and boil until a little mixed with cold water gives a clear, amber colored liquid. Add water to make up to the five gallons.

This is our stock solution. In spraying with Paris green or Bordeaux mixture take two gallons of this mixture, dilute it to 10 gallons and add *to 50 gallons* of spray.

SOAP: Ordinary soap is a valuable contact insecticide.
Formula:

1 Pound Ivory soap or other soap of known quality.
14 Gallons of water.

Boil the soap in five or six gallons of water until dissolved; dilute with water to 14 gallons and spray while still warm. It is recommended for plant lice, red spider, etc.

SULFUR:
Flowers of sulfur is often dusted on plants to prevent such diseases as the powdery mildews.

TANGLEFOOT: Is a sticky material often used on trunks of trees, etc., to prevent caterpillars from crawling up to the leaves, or to prevent wingless females of some insects crawling up the trunk to lay their eggs.

TOBACCO: Tobacco is a very important contact insecticide. As a powder it is one of the best remedies for root-lice on trees. It may also be used in the form of dry stems applied in the same way as the dust. As a decoction of the stems, it may be used as a spray against plant lice. This decoction is also good for lice on cattle. Tobacco smoke, when generated in an enclosed space, kills numerous soft-bodied insects. There are several commercial forms of tobacco decoctions on the market, namely Nicotine and Nicofume, the latter very highly recommended by green house men for the green fly on lettuce. We have found it excellent for all kinds of plant lice.

WHALE OIL SOAP: This is a commercial product, and is a good contact insecticide, particularly for soft-bodied insects like plant lice and slugs.

Insects and Diseases.

Apple.

CODLING MOTH: The larvae of this moth are the ones that make the most of our wormy apples. The larvae leave the apples in the fall and hibernate in cocoons, usually under loose bark of the trees. The adult lays eggs on the leaves or young fruit soon after the blossoms fall. Over ninety per cent. of the larvae find their way into the calyx end of the fruit. Here they eat their first big meal. Consequently if one can fill this calyx cup with a poison, *practically* all of the first generation of larvae will be killed, and the

small number remaining will not seriously injure the fruit later. Any of the arsenical insecticides can be used.

CURCULIO: In this state the curculio that works on the apple is the plum curculio. The adult curculio hibernates, and on the approach of warm weather in the spring is ready to take its first meal. At this time they will attack the swelling buds, consequently if the buds are covered with an arsenical insecticide many curculios will be killed. Later the female curculio lays the egg in the fruit, and then makes the familiar crescent-shaped mark. The egg hatches into a grub, making the fruit eventually drop. If the young fruit can be kept covered with an arsenical spray many less eggs will be laid, and many adult female curculios killed at this time.

SCALE INSECTS: The principle scale insects found in this state are the oyster-shell scale and the scurfy bark louse. The San Jose scale is probably present, as it has been found in the states surrounding Minnesota. These are sucking insects, consequently a contact or gaseous insecticide must be employed against them. The insects are covered with a scaly armor that ordinary insecticides will not penetrate. Fortunately the discovery of the lime-sulfur wash has very nearly solved the difficulty with these pests. The lime-sulfur attacks the scaly armor and kills the insect or the eggs beneath. The diluted lime-sulfur wash or the self-boiled is excellent to keep these insects in check during the growing season.

SCAB: This fungus attacks fruit, leaves and young twigs. On the fruit small, olive brown patches are first formed. These later rupture the skin of the apple and large scabby spots or cracks are formed. These permit the entrance of rots later. On the leaves and twigs dark patches of velvety texture are formed, sometimes with an olivaceous tinge. The disease probably lives over on the fallen leaves and, possibly to a certain extent, on twigs and fallen fruit. It is liable to be especially prevalent when the weather has been damp and cool.

If the disease has been very bad the previous year, a thorough spraying with copper sulfate before the buds swell may be advisable. Under ordinary *circumstances* a spraying with 4-4-50 bordeaux

before the flowers blossom, another after the petals have fallen, and a third about ten days or two weeks later, followed by a fourth will probably be sufficient. Self boiled lime sulfur and iron sulfide mixtures have also been used with considerable success.

RUST: This is usually formed on the leaves, producing orange colored spots; it may also be found on the fruit, and, less frequently, on the twigs. If examined closely, the orange spots are seen to consist of many cup-shaped bodies with fringed edges. It is especially bad on wealthy apples when it attacks the blossom end of the fruit. The rust lives over the winter on the red cedar, which it produces the so-called cedar apples from which infection of the apple again takes place in the spring, especially following moist weather.

Spraying for scab will keep this in check to a certain extent, but not completely. Obviously, however, red cedars, whenever possible, should be removed from the vicinity of the orchard, or at least the cedar apples should be cut away early in the spring or late in the fall. If the latter is not effective, the cedar trees must be removed. Neighbors should co-operate.

BITTER ROT—RIPE ROT: This rot is found on fruit and branches. On the fruit it appears first as small, brownish patches beneath the skin. These patches rapidly enlarge until they are of considerable size; they then form sunken, often wrinkled areas, which are often corky, and very bitter around the edges. The fruit is especially liable to attack while it is ripening, but may become infected earlier. Hot, damp weather is very favorable to the spread of the disease which may cause great loss within a week or ten days from the time it first appears.

On the branches it forms cankers which are usually round or somewhat elongated spots, sometimes several inches long. The bark becomes very dry, cracks, and causes a characteristic sunken, wrinkled appearance. The disease probably persists largely in these cankers, but also on the "mummied" fruit.

All rotted apples should be destroyed and the cankered twigs pruned out. If spraying to prevent this disease alone, it would probably be early enough to make the first application of bordeaux or self boiled lime sulfur about a month after the petals have fallen, and to continue at intervals of about two weeks until the fruit is

nearly ripe. Pruning and destroying the diseased apples, together with the sprays used for scab, will keep the disease in check.

BLACK ROT: This quite closely resembles the bitter rot. It forms brown, sunken areas on the fruit; these are often darker in color than those formed by bitter rot. The brown color changes to a darker color until finally the apple dries out, leaving only a blackish, much shrunken remnant. Beneath the skin, numerous small black dots may be seen. The fungus gains entrance to trunks also, usually through wounds or sunscald cracks in the spring, inflicting such damage that large limbs may be killed. A number of so-called leaf spots are also probably due to this fungus.

The treatment is the same as that for the bitter rot.

FIRE BLIGHT: This is a bacterial disease which is no doubt spread very largely through the agency of insects. When they visit the flower, they may have some of the bacteria adhering to their mouth parts, thus permitting the organisms to get into the nectar, where they multiply with amazing rapidity, finally getting into the twig. Boring or biting insects may also cause the infection of older branches. Affected twigs first present a water-soaked appearance, but later the bark is ruptured and gummy exudations appear. The fruit may also be attacked. The leaves of affected branches yellow and dry, but remain on the twigs; usually they do not fall in the winter.

Pruning in the fall or winter should be resorted to if the disease is prevalent. Precautions must be taken to disinfect pruning knives used, or the disease may be spread by means of them. The wounds should also be properly cared for. For disinfecting use the corrosive sublimate preparation. Prune back six inches or more below the infection. Prune out all infected twigs. Neighbors must cooperate.

LEAF SPOTS: There are various spots which are caused by different fungi. Almost all, if not all, can be controlled by the sprays which are applied to prevent the other diseases mentioned.

POWDERY MILDEW: This mildew has the characteristics of powdery mildews in general. It is usually most prevalent on nursery stock where it may cause considerable damage. As the leaves begin to unfold, an application of ammoniacal copper carbonate should be made. This should be continued at two week intervals.

A COMBINATION TREATMENT FOR INSECTS AND FUNGOUS

PESTS: In dormant season spray with lime sulfur wash. As the buds are breaking spray with arsenate of lead and lime-sulfur (self-boiled), or with arsenate of lead and Bordeaux mixture. Repeat just after blossoms fall. Repeat in two weeks. Repeat at intervals of two or three weeks until the fruit begins to ripen and substitute ammoniacal copper carbonate for the Bordeaux mixture.

Asparagus.

RUST: The most conspicuous stages of the rust appears as brown eruptions, followed later in the season by black, or brownish black patches of winter spores.

It has been observed that the disease is most prevalent on dry soils, so a good rich soil very carefully cultivated and kept fairly moist renders it less destructive. It is also favored by heavy dews, and moist conditions, so there should be good aeration. In the fall all diseased stalks should be collected and burned. Spraying has been partially successful. Resin bordeaux should be applied at intervals of about ten days beginning when the shoots are small. However, while shoots are small and rapidly growing, it may be necessary to spray more frequently.

Bean.

BEAN AND PEA WEEVIL: The beetles usually appear on the vines when the plants are in blossom, the eggs being deposited on the surface of the young pod. The hatched larvae bore into the pod and enter the young seed, where it grows to maturity. In this state the pea weevil probably remains within the seed until planted the next spring. It does not breed in dry peas. The bean weevil, however, will breed in dry beans. For the pea weevil the best remedy is to hold the seed over a year before planting, keeping in a tight receptacle. Fumigating the infested seeds with carbon bisulfide is good. Heat also (130 to 140 degrees F.) will kill the insects in stored material.

ANTHRACNOSE: This produces the familiar reddish brown or darker colored sunken spots on pods, stems and leaves. The disease gets into the seed and is carried over the winter in this way. No seed treatment has been developed, so it is absolutely essential to get seed from healthy pods if the disease is to be avoided. It spreads only when the plants are wet, so no cultivation should be done when there is moisture on the vines. Spraying is of very doubtful value; the essential thing is to get seed from healthy pods.

All plant remains and rubbish should be destroyed in the fall. There is some question as to varietal resistance; wax varieties are said by some to be least resistant while the limas are more resistant.

DOWNY MILDEW: The fungus attacks mostly the pods, but may also be found on the leaves and, in some cases, on the stems. It produces white patches which may become so numerous as to cause the pods to die. In some cases, when the disease is especially severe, it also gets into the seeds. It is pretty well establishd that insects aid very greatly in its spread.

Clean seed should be selected, all old vines should be destroyed in the fall and, if the disease has been particularly bad, a rotation of crops may be necessary. Careful spraying with bordeaux has been found to effectually prevent the occurrence of the disease.

BLIGHT: All above ground parts may be affected by the disease. It is most noticeable on the leaves and pods, producing on the leaves large, irregular brownish patches which later become dry and brittle. On the pods watery brown spots with no very definite boundaries are produced.

The disease is of bacterial origin. The first infection is generally supposed to come from the seed in which the bacteria have lived over, and is then quite largely spread by insects. Seed should be selected from fields in which there was no infection, all affected parts should be burned, and a crop rotation should be practiced.

RUST: Small pustules, about one-sixteenth of an inch in diameter, are formed usually on the lower surface of the leaf. Just opposite these pustules, on the upper surface, pale yellowish spots appear. Later these pustules break open, liberating a mass of dull reddish brown spores. The disease has not been reported as being very troublesome. Burning of dead parts in the fall and clean culture methods should help keep it in check.

POWDERY MILDEW: Grayish patches, appearing as though dusted with a grayish powder, appear. Usually the disease is not very destructive. It can be controlled by means of dusting with sulfur or spraying with potassium sulfide.

Beet.

The principal insects of the beet are the leaf-eating forms, which can be controlled with any of the arsenical insecticides.

LEAF SPOT: Brown spots, with a purplish tinge around the edge and with a grayish center, appear. They may become dry and

fall out, leaving many holes in the leaves. This occurs also on sugar beets.

Spraying with 5-5-50 bordeaux, first when the plants are six weeks old and then at ten-day intervals, gave a large increase in yield over unsprayed plots in the east.

SCAB: See Potato Scab.

Cabbage and Cauliflower.

The principal enemy is the so-called cabbage worm, the larvae of the common white cabbage butterfly. The ordinary arsenical insecticides readily keep these in check.

BLACK ROT: This is caused by bacteria. The first symptons of the disease appear as a yellowing of the edges of the leaves. Later the leaf veins become black, and the outer leaves may fall off, in bad cases leaving the stem with only a few leaves near the top. Moist conditions are especially favorable to the spread of the disease, since the bacteria enter through the water pores at the edge of the leaf. All heads which show signs of infection should be rejected, since a soft rot which may spread to the other heads is likely to ensue. Such heads should not be fed to stock, the manure of which is to be used on land used for raising cabbage. Clean cultivation and rotation should be practiced, since the disease may live over in the soil. It may also be carried over in the seed, so only clean seed should be made. As an extra precaution, seed should be soaked 15 or 20 minutes in formalin, 1 pound to 30 gallons. The same disease occurs also on many other plants of the mustard family, both wild and cultivated, such as shepherd's purse, common wild mustard, kohl rabi, brussels sprouts, kale, rape, turnips, etc. This should be taken into account in attempting to control the pest.

CLUB ROOT: Club root is caused by a slime mold, an animal fungus. It causes, on plants of the mustard family, large swellings or galls on the roots which later decay. The above ground parts are affected by the general decrease in vigor so that, in many cases, they fail to head.

All refuse and diseased parts should be destroyed, and care should be taken not to use manure which may have come in contact with diseased parts. Since the soil, when once infected, may remain so for several years, a rotation should be practiced. An application of air-slaked stone lime, at the rate of about 75 to 80 bushels

per acre, has proven very beneficial. It should be applied a few weeks before planting and should be very thoroughly worked into the soil.

DOWNY MILDEW: The downy mildew occurs usually in the seed bed—seldom in the field. It produces grayish white patches on the under surfaces of the leaves. Opposite the spots, on the upper surface of the leaves, there are yellowish, somewhat shrunken spots. Spraying with bordeaux will control the disease.

Celery.

LEAF SPOT—EARLY BLIGHT: Yellowish, angular spots, with somewhat raised borders, appear on both sides of first the outer and then the inner leaves. As the disease progresses, the centers of the spots become grayish in color; the leaves wilt and dry. Muggy weather is favorable to the spread of the disease.

In order to control it, spraying should be begun early—in the seed bed—and continued at intervals of ten days or two weeks. Either 5-5-50 bordeaux or ammoniacal copper carbonate may be used.

LATE BLIGHT: Leaf spots, similar in the early stages to those of the early blight, appear on the leaves. Later numerous small, black dots appear on the affected portions. The leaves may rot away entirely, either in the field or in storage. The trouble in storage is greatly increased if the celery is kept in moist, poorly ventilated places.

Control measures may be taken as indicated under early blight. It is especially important to begin spraying as soon as the plants come up. If the plants are at all affected, the leaves should be dipped in ammoniacal copper carbonate before being stored.

Cucumber.

CUCUMBER BEETLE: In the adult condition these striped beetles eat the leaves and so can easily be combated with the arsenical insecticides. In the larval form they sometimes do great injury to the roots of cucumbers. We have had good success against this form by using tobacco dust on the exposed roots of the plants.

DOWNY MILDEW: The downy mildew produces yellowish spots, irregular in outline, first upon the older and then upon the younger leaves. In warm weather the spots may spread rapidly, eventually covering the entire leaf, which then dries and may fall.

Flowers are produced, but few fruits are matured, and those which come to maturity are usually small and misshapen.

Spraying to control the pest should begin as soon as the vines begin to run, and should be continued every ten days or two weeks. 4-4-50 bordeaux may be used, although it is often recommended that the first spraying be made with 3-6-50 and the subsequent ones with a 4-4-50 mixture.

POWDERY MILDEW: This produces the powdery patches characteristic of powdery mildews. Usually it is not very destructive and will yield to the treatment applied to control downy mildew.

SCLEROTINIOSE OR SCLEROTIUM DISEASE: In the greenhouse this disease may do considerable damage, although out of doors it occurs but rarely. The stems become soft and yellowish, finally drying up. A white, fuzzy mass may also appear. Slender black storage organs may appear. Affected vines should always be removed before these storage organs appear and the place from which they were removed should be very thoroughly sprayed with bordeaux or some other fungicide.

WILT: This disease is of bacterial origin. It has not been found on cucumbers in Minnesota, but was found on squash in 1910, so a description will be given, since it is probably present. It causes the vines to droop and, finally to die. It is spread mainly by biting insects, and, possibly to some extent, lives over in the soil. Spraying to prevent other fungous diseases and insects will aid in preventing the spread of the wilt. Rotation of crops may also prove beneficial. Destruction of diseased vines is, of course, necessary.

TUBERCULAR OR WART DISEASE: The cucumbers are covered with knob-like protuberances which later may cause the entire fruit to become misshapen. Although considerable work has been done at this Station in attempting to control the trouble, no effective remedy has yet been found.

Currant.

The currant worm, the larva of a saw fly, is the worst insect pest of this shrub. As the insect eats the leaves, however, it is easily combated with a stomach insecticide.

CURRANT APHIS: This plant louse works on the under side of the leaves causing reddish, swollen discolorations. They are quite hard to combat, living as they do, entirely on the under side of the

aves. A contact insecticide must be used, the spray being thrown gainst the lower surface of the leaves.

LEAF SPOT: There are at least two distinct fungi causing leaf spots on currant. The spots are usually circular in outline with a grayish brown center. The leaves may finally fall in serious cases, causing great damage.

To control the disease, spray with bordeaux as soon as the leaves unfold, and continue at intervals of ten days or two weeks until five applications have been made.

POWDERY MILDEW: The fungus produces grayish, cobwebby patches at first. These later become brown and felt like. Leaves, fruit and stem are attacked.

Potassium sulfide used at the rate of 1 ounce to 4 gallons of water is the most efficient spray. Spraying should be begun just as soon as the leaves begin to appear, and should be continued at ten day or two week intervals until at least five applications have been made. It may be necessary to add one or two more applications.

CANKER: The canker is produced as reddish eruptions on the stems; these eruptions may become dark later in the season. Twigs may be killed; in any case vigor is greatly reduced. Pruning may be necessary. However, since the disease enters largely through wounds, care in covering them or spraying with bordeaux, when such wounds occur, will be beneficial.

RUST: Usually the rust is not very injurious. No extensive experiments in controlling the pest have been made, so that only the destruction of affected parts can be recommended.

Ginseng.

BLIGHT: The leaves and stem are both attacked. Large, watery patches are produced on the leaves, and brown cankers are formed on the stem. The disease may spread rapidly and become very destructive. Infection in the spring seems to be caused by the spores which are on the ground. The plants are attaked as they come through the ground, the disease first appearing on the stems. In order to properly control the disease, it is necessary to spray the beds with copper sulfate, used at the rate of 1 pound to 10 gallons of water, before the plants come up. Then, as soon as they push above ground, they should be again sprayed. This should be done every other day until the plants are fairly well along. Resin bor- [illegible] adhere better than the ordinary mixture.

WILT: The leaves wilt, become yellowish and finally die. The stems become black and defoliated. Great damage may be done within a week. It is said that the disease will not appear unless the plants are weakened by the attacks of other fungi. Spraying for the blight should also keep this disease in check.

Gooseberry.

See Currant.

Grape.

LEAF HOPPERS: These are very active, insidious sucking insects, and consequently hard to combat. A contact insecticide, like kerosene emulsion or miscible oil will keep the insect in check.

BLACK ROT: The disease first appears on the leaves; it produces nearly round, tan colored or brown patches. Later it attacks the berries on which it appears first as small, brown or purple spots. These spots enlarge very rapidly until the entire fruit is covered. The skin does not usually rupture, but the berries shrink until they remain only as wrinkled, hard, dry mummies. Young shoots may also be attacked; in this case the spots are usually reddish and may cause a splitting of the shoot. The disease lives through the winter on affected parts; consequently all of these should be sprayed in the fall, and clean cultivation should be practiced. Just as the buds are beginning to swell in the spring, a very thorough spraying with bordeaux should be made. When the buds are unfolding, the second spraying should be given with 4-3-50 bordeaux, and this should be repeated at ten day or two week intervals. The number of sprayings necessary depends upon weather conditions; in warm, moist weather the disease is most destructive. If it is necessary to continue spraying until late in the season, ammoniacal copper carbonate should be substituted for bordeaux the last two times. This is done in order to avoid the spotting of the fruit.

DOWNY MILDEW—GRAY ROT: The symptoms are those usually appearing as a result of downy mildew. A grayish, felty mass of fungus threads appears on leaves and berries. The berries eventually shrivel, but do not become hard and dry as in the black rot. If they are attacked after they are at least two-thirds grown, they become brown in color; for this reason the name brown rot is sometimes applied.

The control measures indicated under black rot will suffice. It *is especially* important that spraying be begun early in the season.

moist seasons irregular brown or black spots aves. They appear first on the under surface trol measures indicated under black rot.

EW: The powdery mildew appears as circular, n all above ground parts of the plants. Under conditions it may become serious, since the flow- ed and then fail to set their fruit, while the berries e attacked and then cease growth, finally dropping Lack of ventilation, excessive shade and damp situ- ally favorable for the spread of the disease.

n flowers of sulfur when the blossoms begin to open stings as occasion may demand usually controls the The treatment under black rot is also effective.

NOSE—BIRD'S EYE: This appears on the canes as pots with sunken, ash colored centers; it weakens the eatly. The symptoms on the fruit are very much like canes. The spots often have reddish edges. The dis- should be cut out as soon as they appear. In addition, black rot.

Lettuce.

MOLD: The disease first becomes apparent by reason of edges of the leaves. Later the affected leaves may droop becoming covered with a dirty, brownish gray fuzz. Proper methods and care of the greenhouse will generally prevent earance of the disease. Good ventilation and a fairly con- mperature, which must not be too high, are essential.

LT: Healthy lettuce in the greenhouse may succumb to this a single day. Affected leaves appear as though they had uddenly plunged into boiling water and then taken out again. se, white growth of fungus threads appears on parts which ollapsed. The fungus produces storage organs which persist hout the winter, causing infection the next year. All affected s should be removed in order to prevent the formation of organs. The same general sanitary precautions mentioned gray mold should be taken. In case the soil becomes infected, ld be disinfected with formalin used at the rate of 1 pound ½ gallons of water; it may be necessary to change the soil y.

Melons.

e *Cucumber.*

Onion.

BLIGHT—DOWNY MILDEW: Warm, moist weather is especially favorable to the spread of the disease. The tips are first attacked, presenting a water-soaked appearance, which is followed by a fuzzy outgrowth. Later the plants may collapse entirely, thus preventing the formation of normal bulbs.

Crop rotation, clean culture and spraying will prevent the disease. If it has never appeared before, it may not be necessary to spray before the disease appears, but upon the first indication of its appearance 5-5-50 bordeaux should be applied. One spraying may or may not be sufficient, depending on weather conditions.

SMUT: The smut persists in the soil, so is particularly liable to attack seedlings upon which it causes the formation of black, dusty patches of spores. Rotation is beneficial as is soil treatment with lime used at the rate of about 100 bushels per acre. Treating seed with formalin at the rate of 1 pound to 30 gallons of water is also beneficial.

Pea.

See Bean.

Plum.

1. PLUM CURCULIO: (See plum curculio under *Apple*).
2. SCALES: (Same as under scale on *Apple*).

BLACK KNOT: This disease is prevalent on both wild and cultivated plums and cherries. The first indication of its presence is usually the development on young twigs of velvety, greenish or olive colored swellings. These later in the season become black and brittle. Not only young twigs, but also larger branches may become affected. The branches may be killed on account of the interference with the transportation of nourishment, or their vitality may be lessened. Infection probably takes place largely through wounds and abrasions, so all of these should be carefully avoided. Further, the disease spreads most rapidly while the knots are still young, so that careful pruning before they have had time to develop is necessary. If any have been missed, they should be removed later. Pruning alone, however, is not sufficient to control the disease, since it occurs also on wild plums and cherries. Spraying should also be practiced. The first application should be made in the late winter or early spring while the trees are still dormant, another should be made when the buds begin to swell, while the *others* may be made as necessity demands. For the first spraying

6-6-50 bordeaux mixture should be employed, but this would be almost sure to injure the foliage on the trees later in the season. A 3-4-50 mixture of bordeaux is sometimes used without foliage injury resulting, but even this mixture may in some seasons be injurious. Even the weaker solutions proved injurious in experiments conducted by the Pathology Department in 1910. Although its worth on plums has not yet been absolutely demonstrated, self boiled lime sulfur has given much promise and should be tried.

BROWN ROT: Although brown rot is especially destructive on fruit, it occurs also on leaves and twigs, causing a blighted appearance and finally killing them. The fruit is more especially susceptible in the later stages of its development, moist weather being very favorable to the spread of the disease. Small, brownish spots first appear; these enlarge rapidly until the entire fruit may be covered. Upon the surface of the fruit brown patches of spores appear; these spores may be blown long distances, thus spreading the disease. The diseased fruits finally shrivel and dry, often remaining on the tree indefinitely. Infection in the spring is caused largely by these mummied plums, which should, of course, be destroyed.

Spraying should be carried on as for black knot; the self boiled lime sulfur mixture has proven effective in controlling the same disease on peach, and will probably prove efficient when used on plums. Naturally, since plums are more liable to become infected after they are at least half grown, spraying should be continued until late in the season.

FIRE BLIGHT: (See *Apple*).

PLUM POCKET: The fungus attacks the fruit, destroying the pit and converting the entire fruit into a hollow, bladder like sack which later falls from the tree. Twigs may also be infected, and it is supposed that the disease hibernates mainly in this way. The disease apparently does not spread very rapidly, so that pruning out and destroying affected parts, together with the spraying for brown rot and black knot, will help keep it in check.

POWDERY MILDEW: (See *Apple*).

SCAB: Dark brown, scabby spots appear on the surface of the fruit, especially in a rainy season. The disease will yield to the treatment given for brown rot.

SHOT HOLE: Very numerous, rather small, brown spots ap-

pear on the leaves. These later become dry, and the dried portions may fall out, leaving the leaves with the appearance of having been riddled with shot, whence the common name. The chief damage done is in the enormous decrease of leaf surface and the defoliation of the tree. It has been found that 2-4-50 bordeaux or 8-8-50 self boiled lime sulfur will effectively control the disease if spraying is begun early and continued throughout the season at intervals of about two weeks.

COMBINED TREATMENT FOR INSECTS AND FUNGUS PESTS: Lime sulfur wash in the dormant season. Arsenate of lead and lime sulfur (self boiled) as the buds begin to swell. Repeat at intervals of two weeks until fruit is ready to harvest.

Potato.

COLORADO BEETLE: This striped pest hibernates in soil. As the potatoes show above ground the beetles are on hand to lay the yellow patches of eggs on the underside of the leaves. The greasy looking grubs are the ones that do the damage. An arsenical insecticide will kill them easily, especially if the spray is applied while the larvae are still small.

EARLY BLIGHT: The disease is confined to the leaf. upon which grayish, dry spots are produced. Usually the spots are characterized by the presence of concentric circles. Although the tubers are not affected, the effect on the leaves may be so serious as to very greatly diminish the leaf surface, thus making it impossible to form normal tubers. In dry seasons considerable loss may result if the vines are not properly sprayed. Control consists of proper spraying with bordeaux; when the plants are young, a 4-4-50 mixture should be used, but, after the first two sprayings, a 6-6-50 mixture may be used. The idea is to keep the vines covered with bordeaux from the time they are about six inches high until the end of the season. It is uncertain, at the present time, whether or not in Minnesota it would pay to spray to control this disease alone.

LATE BLIGHT: Late blight has, fortunately, not yet become serious in this state, except when the weather in August is exceptionally wet. The leaves and tubers are both attacked; on the leaves the disease appears first on the edges, blackening and drying there while on the tubers dark, sunken spots are first developed, followed later by a dry rot or a soft, foul smelling rot which may continue

after the tubers are stored. Only clean, healthy tubers should be selected for seed, and spraying should be conducted as for early blight, except that when spraying for late blight alone, it may be begun later in the season.

SCAB: Affected potatoes show rough, corky patches which may, in severe cases, be cracked. The yield may be somewhat affected, but a greater loss is due to the decreased value of potatoes. It is necessary to remember that beets and turnips are susceptible to the same disease and that the disease persists not only on the tubers, but also in the soil. No susceptible crop should be planted on infected land for at least three years and preferably longer. Seed potatoes should be soaked for two hours in formalin used at the rate of 1 pound to 30 gallons of water. The tubers may then be dried, cut and planted. They should not again be brought into contact with anything which contained them before they were treated. Thirty gallons will usually treat about 45 to 50 bushels of potatoes. Corrosive sublimate may also be used, but, on account of its poisonous nature, is not so desirable as formalin.

TIP BURN: This is a disease which is not induced by any parasitic organism. The tips of the leaves dry and break off during hot, dry weather, especially if the crop is on light soil.

WILT—INTERNAL BROWN ROT: The disease is caused by a fungus which may live in the soil and gain entrance through the roots. The vines wilt, and, when pulled up, the roots usually break off very easily. The disease may be in the tubers at harvest-time without showing conspicuous symptoms. However, when stored in warm places where considerable moisture is present, it may spread very rapidly, at first forming a yellowish or black ring near the stem end; and later the entire interior may be converted to a dry, shrivelled mass. Bacteria also very often gain entrance and aid in the rotting process. Potatoes from wilted vines are very liable to be infected, so they should be examined and if they show a brown discoloration beneath the surface of the stem end, they should be used at once, as at this stage they are not unfit for eating. In any case, tubers should be stored in a dry, cold place.

In controlling the disease, affected vines should be removed and destroyed, no affected tubers should be used for seed, and crop rotation should be practiced. It is not definitely known how long soil will *remain infected, but it is* probable that several years will be

necessary to remove danger of infection from this source. It is important in planting seed to be careful to get clean seed.

WILT—BACILLOSE: The symptoms in the field are somewhat like those just given for internal brown rot. The leaves dry, and the stems and tubers become yellowish or black, exuding a soft, pus-like substance when broken. The disease is spread largely through the agency of insects, so it is especially important to guard against them. The same precautions regarding storage, soil and planting, which were mentioned under internal brown rot, apply here.

COMBINED TREATMENT FOR INSECT AND FUNGUS PESTS: Paris green and bordeaux mixture when plants are six inches high. Repeat at intervals of two weeks during the growing season.

Radish.

MAGGOT: This is a very hard insect to combat. The adult insect looks very much like a house fly. The eggs are laid on the soil near the base of the plant, or on the base itself. Early planting and [illegible] are the best preventives. But see article on page 55.

[illegible] (See *Cabbage*).

[illegible] Upon radish leaves, especially in the green-[illegible] Blisters may appear on the leaves. The flowers [illegible] swollen and otherwise misshapen. All re-[illegible] parts should be destroyed.

Raspberry and Blackberry.

[illegible]: This fungus produces on the young canes the [illegible] spots. Later in the season the spots become gray-[illegible], remaining purple around the border. As the [illegible] in size, they may girdle the cane, eventually killing it [illegible] interference with the water supply. Leaf petioles, the [illegible] and the leaf blades may also become infected. The [illegible] by anthracnosed canes are usually small and dry. [illegible] their premature ripening.

[illegible] should not be grown on the same soil more than [illegible] the disease is troublesome. The affected canes should [illegible] burned. Resin bordeaux may be applied early in the [illegible], it will not prevent the disease.

[illegible]: Crown gall is a bacterial disease, producing on

: roots of raspberries and other plants the well known swellings or lls. From its very nature it would be extremely difficult to con- l when once established. All affected plants should be pulled up d burned. Only healthy nursery stock should be planted on land ich has not recently grown raspberries or blackberries. From : most recent researches on this disease it seems possible that spberries may become infected from affected apple trees.

LEAF SPOT: Numerous small, light colored spots, with darker rders, often appear. In the center of the spots small black dots e often visible. Usually the disease is not serious, and the value spraying is not known.

RUST: The rust appears in its most conspicuous stage as bright d patches on the lower side of leaves, distorting and rendering em worthless. The fungus threads may live in the canes for a mber of years, so that spraying is of value only in preventing read to other plants. All affected parts should be removed and rned.

Shrubbery.

Plant lice often attack the leaves of shrubs, but any contact in- cticide, like a soap solution, or nicofume will keep them in check.

"RED SPIDER": These little pests are very bad in a dry season. praying with ordinary water will keep them in check.

Squash.

See Cucumber.

Strawberry.

LEAF SPOT: The common large leaf spot, with a purplish rder and lighter colored center, is usually very prevalent. It may : controlled by spraying with bordeaux once before the blossoms en and once or twice after the fruit is picked. In the late fall or rly spring, the leaves may be cut off and then burned. See Spray lendar, page 174, for insects.

Sweet Peas.

PLANT LICE: As in the case of shrubs the lice on sweet peas n be kept in check by soap solutions, tobacco products or ordinary ater.

Tomato.

WORMS: These are larvae of a large moth, often called hum- ing bird moth because of its habit of hovering over flowers and

sucking the nectar therefrom. It flies usually toward evening at dusk. Usually the larvae are not in sufficient numbers to warrant spraying. Hand picking will keep the pests in check.

LEAF SPOTS: A number of leaf spots occur on tomato, but they have not been serious in this state. Spraying with bordeaux will prevent them, if begun about ten days after transplanting and continued at intervals of about two weeks.

POINT ROT: The point or blossom end rot causes great damage in dry seasons. It appears on the blossom end of the fruit as sunken, brownish spots which may increase rapidly in size until the entire fruit is rotted. The cause of the disease has not been fully worked out, but it is known to be most prevalent on light soils during hot, dry weather. Spraying is of little value; sub-irrigation gives some relief.

RIPE ROT: This causes the black rot so common on the ripe fruit. Spraying for leaf spot smay prevent its appearance to a certain extent. The vines should be carefully trained so as to permit of sufficient aeration.

Turnip.

BLACK ROT: (See *Cabbage*).

CLUB ROOT: (See *Cabbage*).

SCAB: (See *Potato*).

SPRAYING MACHINERY.

An individual may understand thoroughly all about insecticides and fungicides and their application, and yet unless he is the right kind of man, or has the right kind of machinery to put the material on the plant in proper form, his knowledge avails him nothing. A spray pump may be capable of applying the spray correctly and economically for a period in one orchard, and not be the right kind for another orchard. Again, one kind of pump may suit one orchard, and good, clean fruit be the result, though perhaps the pump is not as good as that of his neighbor, who sees no good in spraying because his fruit is spotted or worm eaten. With the present day advance in all kinds of machinery, it often pays a man to practically give away an old machine for a new one of more efficient pattern which may be better suited for the work in hand. Spraying, therefore, is a question of individuality and spraying *machinery*

For orchard work, it is never advisable to purchase anything maller than a barrel pump. A good barrel pump will last a life ime, and can be used for purposes other than spraying, such as vhite-washing, disinfecting, etc. Always wash the spraying apaaratus out with water after spraying or white-washing and oil and lean up all parts before putting away for winter.

When an orchardist has a sufficient number of trees to require ive or six barrels of liquid for one spraying, it is advisable to purchase a large tank, holding 200 to 300 gallons and a double-acting sprayer; or better, if he can afford it, a gasoline sprayer.

Some essentials of a good spraying apparatus are:

1. The pump should be brass lined to prevent corroding or rusting of parts.

2. The pump must have a sufficiently large air chamber to keep the pressure uniform, one that will, with comparative ease, keep, with two leads of hose in operation, a pressure of at least 150 pounds.

3. As the principal ingredient in many of the insecticides and fungicides is the fine material held in suspension, there must be perfect agitators that will keep the liquid in constant motion.

4. The nozzle must be the best that is suited to the occasion. The nozzles of the "Bordeaux" type are not very satisfactory in ordinary usage. The "Vermorel" gives an excellent fine spray, but often is misty too soon after leaving the nozzle. The larger type nozzles, like the "Mistry" are more satisfactory for much of the orchard spraying.

5. Another very important point in spraying is to have a good hose. Often a poor or worn-out hose causes more trouble than all the rest of the apparatus put together. Good hose bands to hold the hose on the couplings, and long hose couplings are essential. A short hose coupling is often more trouble than it is worth.

6. Bamboo extension rods with cut offs at the lower ends are necessary in orchard spraying. The rod inside the bamboo is made either of iron, brass or aluminum. The latter are lighter to handle, and when properly made are excellent. Extension rods can be obtained from eight to

Plant.	Pest.	Spray.	First
Apple.	Codling moth.	Arsenate of Lead (3-50).	Just after th fall.
	Scale Insects.	Lime Sulphur. (Boiled.)	After the lea in fall.
	Curculio (Plum).	Arsenate of Lead (3-50).	Just as the breaking.
	Scab.	Lime Sulphur. (Self boiled).	Before blos open.
	Bitter rot.	Bordeaux mixture.	When app grown.
Asparagus.	Rust.	Resin Bordeaux mixture.	After crop
	Beetles.	Arsenate of lead.	After crop
Cabbage. Cauliflower.	Cabbage worm.	Arsenate of Lead (3-50). Plus resin lime mixture.	Whenever t appear.
Cucurbits.	Mildew.	Bordeaux mixture.	Middle of Ju
	Cucumber beetle.	Arsenate of Lead (3-50).	As soon as pear.
Currant. Gooseberry.	Currant worm.	Arsenate of lead or Hellebore.	When insect
	Mildew.	Bordeaux mixture or Potassium. Sulfid (Liver of Sulphur).	Before leaf
Grape	Mildew.	Bordeaux mixture.	Before blos out.
	Leaf hopper.	Some miscible oil or kerosene emulsion.	As soon as p their appe
	Brown rot.	Bordeaux mixture or lime sulphur.	Just before (Bordeaux
Plum	Plum pocket.	Copper sulphate and Bordeaux mixture.	Copper sulp any grow spring.
	Curculio.	Arsenate of Lead.	Same as for
	Scale Insects.	Lime sulphur (boiled).	Same as fo
Potato	Blight.	Bordeaux mixture.	When plant inches hig
	Beetle.	Paris green (1-50), or arsenate of lead (4-50).	As soon as hatch.
Raspberry. Blackberry.	Anthracnose.	Bordeaux mixture.	Before leave
Shrubbery.	Red Spider.	Water or some tobacco decoction.	As soon as
	Powdery mildew.	Ammoniacal Copper Carbonate or Potassium Sulphid.	Spray as so appear.
Strawberry.	Leaf roller.	Arsenate of lead.	Early in t season.
	Leaf Spot.	Bordeaux mixture.	Before bloss
Sweet Pea	Plant lice.	Soap solution or nicotine liquid.	As soon as
Tomato	Tomato-worms.	Arsenate of lead (3-50).	Apply when pear.

RAY Time.	Third Time.	Fourth Time.	Remarks.
ter.	Last of July.	10 days later.	The first spraying is the most important and should be a drenching spray forcing the liquid into the calyx cups.
s burst			Trees should be thoroughly covered.
fruit	10 days later.	One month before harvesting.	
soms	10 days later.		
ter.			
ater.	2 weeks later.	2 weeks later.	Two or three sprayings, usually are all that are necessary. The tops should be burned after the first freeze in the fall.
			Some shoots left larger than others will attract beetles to breed there. Destroy these traps.
en nec-			The arsenical used in soapy water will make the poison stick better to the leaf. There is practically no danger in using Paris green or arsenate of lead on cabbages, one reason is because of its method of growth. With cauliflower greater care to be taken if plant is heading.
ter.	10 days later.	10 days later.	
en nec-			For larvae on roots, use Tobacco dust or decoctions.
			When berries begin to turn it is better to use Hellebore.
soming.	10 days later.	10 days later.	In first sprayings use Bordeaux mixture. At third spraying Liver of Sulphur is best.
iit has	2 weeks later.		
later ves are Lime S.)	2 weeks later (Lime Sulphur).	2 weeks later (Lime Sulphur).	Destroy all mummies.
mixture growth			Remove 6 inches from ends of all twigs in fall and burn.
ater.	2 weeks later.	2 weeks later.	Keep up every two weeks during growing period.
en nec-			
canes a ordeaux (2-3- ks later.	Same 2 weeks later.		Cutting out diseased canes and burning is the essential part.
s later.	10 days later.		Water sprayed on plants having red spiders is as effective as any spraying compound.
er.	10 days later.	If necessary, 10 days later.	
ter.			
later.	10-14 days later.		
ter.			Spray should be very fine and put on forcibly. A spray of water alone is often very effective.
			Hand picking is ordinarily all that is necessary.

fourteen feet long, but it is not often advisable in this state to purchase one over ten feet.

7. A *necessity* when spraying compounds are used is a good strainer. A fine mesh brass screening set at an angle in the frame of a box is the simplest and best.

Cost of Spraying.

The cost of spraying varies in different localities, depending upon wages, the topography of the land, with the size of the spray machine, the size of the trees, the distance from water used in the spray material, etc. The cost will vary between the different kinds of large and small outfits, from five to fifteen cents per tree for each spraying.

The following is a list of companies to whom the prospective purchaser may write for catalogues and prices.

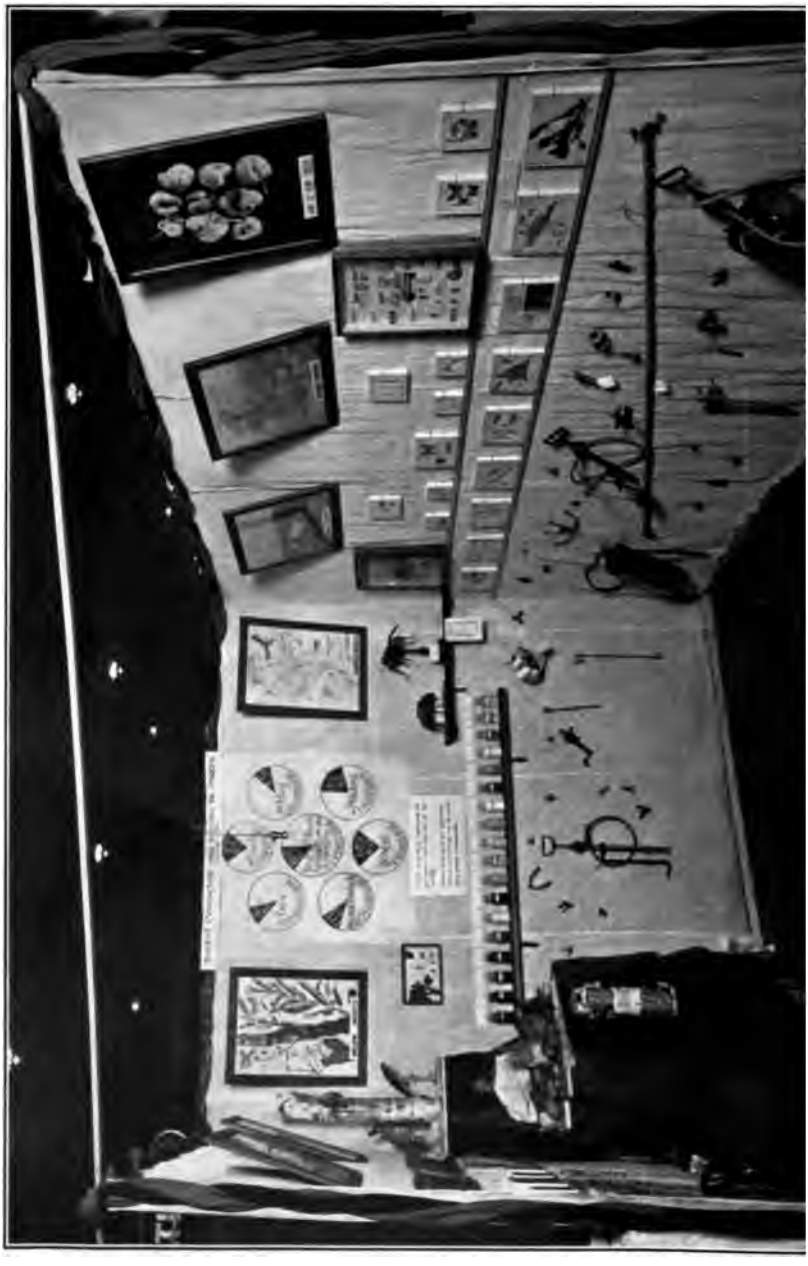
Spraying Machine Manufacturers.

American Sprayer Co., Minneapolis, Minn.
Barnes Mfg. Co., Mansfield, Ohio.
Bean Spray Pump Co., Cleveland, Ohio.
Binks Spraying Machine Co., Chicago, Ill.
Brandt Manufacturing Co., Hastings, Minn.
E. C. Brown Co., Rochester, N. Y.
Cushman Sprayer Co., Lincoln, Nebr.
Dayton Supply Co., Dayton. Ohio.
Deming Co., Salem, Ohio.
R. H. Deyo & Co., Binghampton, N. Y
W. & B. Douglas, Middleton, Pa.
Fairbanks, Morse & Co., St. Paul, Minn.
Field Force Pump Co., Elmira, N. Y.
Friend Mfg. Co., Gasport, N. Y.
Gilson Mfg. Co., Port Washington, Wis.
Goulds Mfg. Co., Seneca Falls, N. Y.
Hardie Mfg. Co., Hudson, Mich.
Hurst Mfg. Co., Canton, Ohio.
International Harvester Co.
Latham & Co., Sandusky, Ohio.
Leggett & Brother, 301 Pearl St., New York City.
Morrill & Morley, Benton Harbor, Mich.
F. E. Myers & Bro., Ashland, Ohio.
The New Way Motor Co., Lansing, Mich.
Niagara Sprayer Co., Middleport, N. Y.
Olds Gas Power Co., Lansing, Mich.
Pierce Loop Co., Northeast, Pa.

Splittstosen Mfg. Co., North Branch, Minn.
Spramotor Co., Buffalo, N. Y.
Wm. Stahl Sprayer Co., Quincy, Ill.

Insecticide and Fungicide Manufacturers.

Ansbacker & Co., 253 Broadway, New York City.
Bowker Insecticide Co., 43 Chatham St., Boston, Mass.
Fergusson Bros., 109 Chestnut St., Philadelphia, Pa. (Copper Sulphate).
Good, James, 934-936 N. Front St., Philadelphia, Pa., (Fish oil soap).
Grasselli Chemical Co., 172 E. 5th St., St. Paul, Minn.
Hemingway's London Purple Co., 133 Front St., New York City.
Kentucky Tobacco Produce Co., Louisville, Ky.
Fred. L. Lavanburg, 100 William St., New York City.
Merrimac Chemical Co., 33 Broad St., Boston, Mass.
Niagara Spraying Co., Middleport, N. Y.
Sherwin-Williams Paint Co., Minneapolis, Minn.
Talmadge, Geo. E., Inc., Madison, N, Y. (Aphine).
Taylor, E. R., Penn Yan, N. Y. (Fuma Carbon bisulfid).
Thomsen Chemical Co., Baltimore, Md., New York.
Thum O. & W. Co., Grand Rapids, Mich.
Vreeland Chemical Co., 50 Church St., New York City.



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FOURTEENTH REPORT

OF THE

STATE ENTOMOLOGIST

OF

MINNESOTA

TO THE GOVERNOR

FOR THE YEARS 1911 AND 1912

EIGHTH REPORT OF F. L. WASHBURN

GRASSHOPPERS AND OTHER INJURIOUS INSECTS OF 1911 AND 1912

AGRICULTURAL EXPERIMENT STATION
ST. ANTHONY PARK, MINN.
DECEMBER 1, 1912

LETTER OF TRANSMITTAL

STATE EXPERIMENT STATION,
ST. ANTHONY PARK, MINN.,
DECEMBER 1, 1912.

To His Excellency, A. O. Eberhardt, St. Paul, Minn.

DEAR SIR:—I have the honour to submit herewith the Fourteenth Report of the State Entomologist of Minnesota, covering work of this office and insect conditions during 1911 and 1912.

During the year 1911 we experienced a culmination of grasshopper injuries begun in 1909 and 1910 and had it not been for opportune rains occuring in May and June, Minnesota would have lost, in 1912, thousands of dollars from the depredations of this insect. The present year has seen but little loss from this pest, but two or three dry summers in succession, similar to 1910 and 1911, will again furnish us with enormous hordes of these destructive pests to agriculture.

We have carried on field work during 1911 and 1912 against these insects and are glad to report successful results in that we have found a method (a modification of that practised in South Africa) by which the individual farmer can protect his crops from excessive grasshopper injuries. Several thousand posters describing this method have been mailed to farmers over the state. For full account of this work see page 1.

In this connection, since their abundance in destructive numbers depends largely upon the abundance of grasshoppers, upon the eggs of which they feed when young, we may well mention here the occurrence of one or more species of Blister Beetles. In 1911, beginning about June 1st, they became exceedingly abundant and destructive. They are general feeders, attacking potatoes, peas, clover, grain, shrubbery and particularly alfalfa. For detailed discussion of this pest, see page 44.

In 1911 Cut Worms of several species were extremely numerous and destructive. This we believe was due to two causes, primarily because the preceding season was dry and not conducive to

the spread of fungous diseases among these caterpillars, and ondarily to the slow growth of vegetation in the spring of 1911. has been many years since cut worms have been as abundant a 1911. Complaints in that year began to reach us about May rapidly increasing in number until about May 28th, at which t letters regarding this pest rapidly fell off, although some inqui were received during the first half of June.

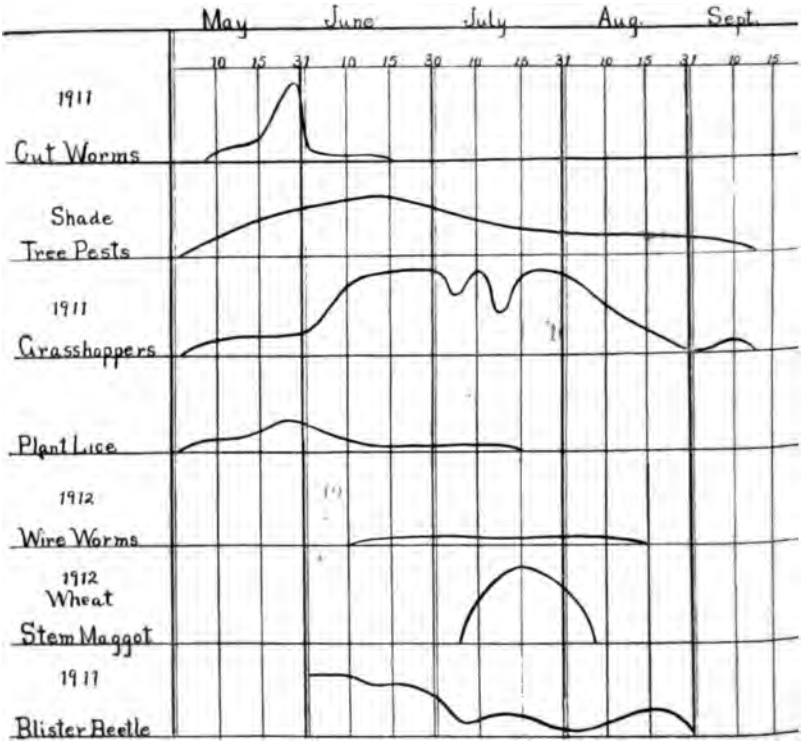


Diagram showing when certain insects were most troublesome as evidenced by complaints in 1911 and 1912. Pests not dated were present both years.

The Wheat-head, Army Worm, so abundant and destructive 1910, was not reported in 1911 and 1912.

The Wheat Stem Maggot, causing "bald heads" in wheat, and barley, has been unusually common during the summer of 1 and caused some alarm amongst our farmers. Except, however, very few instances its injury was, as usual, only infinitestimal, from about July 5th to August 5th our mail was crowded with quiries relative to the maggot, the greater number of letters be *received the* middle of July. The insect is confused with two oth

joint worm working in wheat, and also the Hessian fly; in very
ıny instances the work of the wheat stem maggot was ascribed to
nt worms. Farmers can easily distinguish the work of the form-
from the latter by the fact that while the wheat stem maggot is
ınd in the stalk, the larva of the Hessian Fly, as is attested by the
ation of the so-called "flax seed" is always on the outside of the
lk, next to it, under a sheathing blade. See page 45 for further
cussion of the wheat stem maggot.

The years 1911 and 1912 have witnessed great mortality
ongst our shade trees, the pride of the State, and this passing of
:s, maples and elms is perhaps the most serious problem which
ıfronts the Entomologist today. The Entomologist, however, is
alone in the battle, for various fungous diseases belonging to the
ıvince of the plant pathologist are playing a very important part,
l in some instances possibly the leading part, in the death of our
es. Two circulars have been issued from this office treating on
leading insect pests of shade trees. These circulars can be ob-
ned by any citizen of the state for the asking. Page 54.

On our apple trees both the Scurfy Scale and the Oyster-shell
ıle are much in evidence and the latter apparently decidedly on
increase. It is to be noted in this connection that while a large
ɔunt of Oyster-shell Scale on a tree is naturally quite detrimental
ts bearing qualities and should be eradicated, this species does
approach in its destructiveness the San Jose Scale. A compar-
'ely small infestation of the latter scale will cause a young tree
lroop and ultimately die, the same tree being able to resist a
dred times as many Oyster-shell Scales.

We have to report the occurrence of a Corn Bill Bug in Minne-
ı, a corn field of twenty-five acres at Shakopee being nearly
:royed by this pest. Page 71.

White Grubs, the larvae of the large May Beetles or "June
;s" have been again abundant and destructive, but the injury in
state this season will not compare with the widespread de-
ıction worked by this pest on corn and other plants in Wiscon-
However, in more than one locality in Minnesota, the White
ıb has, during the biennium just completed, made destructive
ɔads upon agricultural products. In 1912 corn, hay, timothy and
ıtoes were severely injured.

The roots of corn were eaten and the stalks blown over. Timo-
was killed before it could produce seed. Potatoes following
suffered severely. Injury from White Grub was particularly

noticeable between July 1st and October 1st. Thorough cultivation along approved lines is a decided help in connection with this pest, coupled with a proper rotation. As is well known, many birds feed upon White Grubs, and when practicable it is a desirable thing to turn hogs into a field after the crop is harvested. They root out the grubs and devour them eagerly. Page 49.

A very large "Weevil" belonging to genus *Sphenophorus* has worked locally on our wheat this year. See page 45

The Green-striped Maple Worm has in at least one instance defoliated many Maple trees.

Not insects, but coming within our province, upon the ground of their being plant pests, we have to report naked snails or "slugs" as being unusually abundant and troublesome during 1912. See page 111.

During the winter of 1911, field mice were especially destructive, one large land owner losing several acres of young maples as a result of the activity of these creatures. See page 88.

There has been the usual quota of complaints of gophers and moles, the latter at times being quite troublesome.

SPECIAL WORK.

GRASSHOPPER EXPERIMENTS: During 1911 we had in the field four workers and in 1912 two experts and an assistant. We regard this as the most important work of the biennium and feature it as such in this report. See page 1 and colored plates, I, II, and III.

CLOVER-SEED CHALCIS: This insect is quite commonly called "weevil" by farmers and reduces the yield of clover seed in Minnesota to the extent of many thousands of dollars. Our Adams Fund worker, Mr. Williamson, has been investigating this insect both in the laboratory and insectary, as well as carrying on co-operative field experiments with farmers in different parts of the state. These investigations begun several years ago will, we hope, be shortly completed. See page 52.

LARCH SAW FLY: Mr. Ruggles, Assistant Entomologist, is continuing work with this pest which is destroying annually in Minnesota millions of dollars worth of tamaracks. See page 62. He is also studying the life history of a species of an Elm Twig Borer. See page 54 for discussion of certain shade tree pests.

SPRAYING FOR CODLING MOTH AND PLUM CURCULIO: Our constituents urge upon us the necessity for impressing upon fruit *growers the* fact not only that there is actual profit in spraying, but

that spraying is an absolute necessity if one would raise good fruit. To that end we have been continuing work in this line. Page 68.

WORK WITH THE CORN BILL BUG: Page 71.

PUBLICATION OF INSECT LIFE: Page 110.

FLY CAMPAIGN: A state-wide campaign against the House or Typhoid Fly. In the fight against this common and disease-bearing insect, we have co-operated with the State Board of Health. For particulars see page 62.

INSPECTION OF NURSERIES AND FOREIGN STOCK: In 1911 fifty-two nurseries were inspected and $236.25, collected as legal fees of inspection, the same being turned into the State Treasury in accordance with the law. This inspection was done by a specially employed expert, and the work faithfully carried out. In 1912 fifty-six nurseries were examined. The sum of $246.99 collected was handed to the State Treasurer and receipt received therefor. *San Jose Scale in limited amount was found in two instances.* The new quarantine law recently enacted by Congress and becoming operative October 1st, 1912, has a direct bearing upon all Minnesota nurseries as well as upon the entrance of foreign stock. See page 103. Inasmuch as the federal government can under this law quarantine a portion of Minnesota or the entire state if it seems it necessary, thereby preventing the nurserymen from shipping outside of the state, it is evident that the nursery inspector of Minnesota should be given more authority and be allowed to inspect my grounds, compelling the eradication of an insect or plant disease which might render us liable to quarantine. The amount of nursery and ornamental stock shipped into Minnesota is increasing yearly, and its inspection when it arives, places, with other duties, quite a burden upon the entomologist who is deputized by the Federal Board to do this work. From October 1st to December 15th approximately, and during April and May, we are called upon to frequently to inspect material of this sort from Europe that it imposes considerably upon the time and duties of our force. We believe that an expert should be employed as deputy inspector to take charge of all Minnesota inspection, both of domestic and foreign stock, and that some especial appropriation should be made for this work, thus relieving the nurserymen from paying the legal fee now required. *One case examined in* 1911 *was found to contain nest of Brown Tail Moth Caterpillars.* See page 103.

LEGISLATION AFFECTING THE WORK OF THE ENTOMOLOGIST OF MINNESOTA: Mention has just been made of the direct bearing of the quarantine law upon Minnesota conditions. In this connection we may also speak of the insecticide laws, one enacted in Minnesota and the other a Federal insecticide law, covering practically the same ground as the State law, though more comprehensive. Complaint was made by the Entomologist to our State Dairy and Food Commissioner this year (1912) of a certain manufacturer who had placed upon the Minnesota market a consignment of paris green not conforming to our State law, nor to the Federal law.

EXHIBITS: The Entomologist has placed exhibits at the State Fair of 1911 and 1912, featuring grasshopper work in 1911 and campaign against the house fly in 1912. Through the generous cooperation of our staff, the exhibit of 1912, consisting not only of fly traps, etc., but many specimens and models of injurious insects, was extremely successful and our booth was crowded with visitors. We believe these exhibits should be made at all the County Fairs where possible in order to acquaint our citizens with the appearance of our injurious insects and the work of this department.

CORRESPONDENCE AND LECTURES: In 1911 the Entomologist dictated 2741 letters, largely answers of inquiries regarding insect pests. In addition a large number of circular letters were mailed and about 2571 circulars and press bulletins, exclusive of the Station mailing list. This does not include the Thirteenth Report which was sent to approximately 700 addresses in addition to copies sent to comply with individual requests. Experiment Station Bulletin No. 123, (Cutworms, Army Worms and Grasshoppers) representing a portion of the Fourteenth Report, was sent from the Experiment Station mailing office to something like 16,000 addresses. In 1912 we mailed 2253 letters, answering inquiries in addition to over 2507 circulars. The following lectures were given during the biennium:

In February, 1911, before the Y. M. C. A. at Duluth, a lecture on "Insect Pests of Garden, Lawn and Park and How to Destroy Them."

In March, 1911, before the Women's Club, Minneapolis, a lecture on "The House Fly."

In May, 1911, a lecture at Hendrum, Minn., on "Grasshoppers."

On December 27, 1911, Presidential Address before the American Association of Economic Entomologists, Washington, D. C., "*The Relations* of the Station Entomologist to His Environment."

LICATIONS:

1911.

April	Vol. I, No. 4 Minnesota Insect Life
May	" I, " 5 " " "
June	" I, " 6 " " "
July	" I, " 7 " " "
August	" I, " 8 " " "
May	Bulletin No. 123. "Cutworms, Army Worms and Grasshoppers." (Station Publication.)
June	Circular No. 21. "Fleas, Bedbugs, Cockroaches, Carpet Beetles or Buffalo Bugs."
July	Circular No. 22. "New Methods of Combating the House Fly."
November	Extension Bulletin No. 23. "Some Common Insects and Their Control." (Station Publication.)

1912.

March	Circular No. 23. "Mosquitoes, Ants, Silver Fish, and Crickets."
April	Vol. I, No. 9 Minnesota Insect Life.
May	" I, " 10 " " "
June	" I, " 11 " " "
July	" 1, " 12 " " "
August	" II, " 1 " " "
August	Circular No. 24. "The Minnesota Fly Trap."
October	Circular No. 25. "Shade Tree Borers."

Many requests for the Insect and Bird Charts first issued in are still reaching us, not only from points in Minnesota, but many quarters in various portions of the United States.

NSECTARY AND EXPERIMENTAL GARDEN: The insectary and en have again proven their usefulness. Life history experis in connection with clover seed insects, grasshoppers, parainsects and various pests of farm and garden were carried on ıg 1911 and 1912. We have a record of 100 insectary exnents during 1911 and a hundred or more in 1912. During the r year a large amount of accumulated material was sorted and ded.

NSECT COLLECTION: This has been added to each season in 1911, the following additional specimens were accessioned.

Hemiptera	1,400
Odonata	140
Lepidoptera	700
Coleoptera	1,400
Diptera	1,050
Hymenoptera	2,110
Total	6,800

These collections were made in various counties of the State and comprise many species new to our collection and in some instances new to the State. As evidenced above, the largest gain was in Hymenoptera and we hope to have before long an excellent representative collection. We are indebted to Mr. Spooner for his enthusiastic efforts in behalf of the collection not only in its increment, but also along the lines of preparation and classification. The season of 1912 has been so occupied with other work that this feature has not been emphasized, although the collections were added to materially thourgh work in the insectary.

ACKNOWLEDGMENTS: The work of the State Entomologist is so closely interwoven with that of the Experiment Station Entomologist that any acknowledgment must of necessity include station workers. We therefore take pleasure in testifying our appreciation of the help in the work afforded by the Director of the Station and other Station workers. The faithfulness and efficiency of the members of the divisional staff are largely responsible for the amount of work and practical results turned out during 1911 and 1912. The Press has been helpful in co-operating with us where it has been necessary to get timely notice to the public. Nurserymen and florists have met us half way in the discharge of our duties as inspector, and farmers and orchardists when called upon have shown a willingness to co-operate in field experiments. At Fergus Falls during both seasons, the High School authorities have been exceedingly courteous in allowing us laboratory rooms and other facilities.

Mr. H. B. Scammel, acting as deputy inspector during 1911, endeared himself not only to us on account of his gentlemanly bearing and application to his work, but also to the nurserymen of the State for the same reason. Mr. Scammel has left us to take up orchard work in Colorado, which state offers a bigger field in fruit growing interests. Mr. C. S. Spooner, also valued by us for his efficiency, has accepted a position in Georgia offering a much higher salary than he received here.

During 1911 Mr. M. P. Somes, and Messrs. Tanquary, Stone and Zetek did excellent field work against grasshoppers, and in 1912 Mr. C. W. Howard and Mr. Somes also worked on these insects in the field. The results of this work the past two years are embodied in this report, page 1. Mr. Howard is eminently qualified to handle the grasshopper problem, since he was a government entomologist in Portugese East Africa, a position

:upied shortly before coming to Minnesota, where this feature of :omological work is of paramount importance. Mr. O. G. Bab-:k, formerly of the Maryland Experiment Station, is now in ırge of our insectary and is a tireless worker. A large part of : success of our exhibit at the State Fair in 1912 is due to his ef-ts. Mr. Warren Williamson is still engaged in research work on : Clover-seed Chalcis and has obtained some striking results. Mr. George Peake we have a diligent and hard-working assistant. '. Ruggles, who has in charge orchard spraying and shade tree ıts, is away at date of writing on a seven months' leave of ab-ıce, having been called to a postiion on the Chestnut Tree Blight mmission in Pennsylvania.

The colored drawings in the Report (Plates I, II and III) are ithful representations of specimens taken in Minnesota. The cellent work of the artist, Miss I. L. Wood, has been reproduced the engravers with remarkable accuracy of detail.

The custom house officials in St. Paul, Minneapolis and Duluth ve been very helpful in their courteous co-operation in connection th the inspection of foreign stock.

To the Governor of the State and other officials at the State pitol, the undersigned wishes to express his appreciation of rious courtesies.

Respectfully,

F. L. WASHBURN,
State Entomologist.

FINANCIAL STATEMENT,* FISCAL YEAR, AUGUST 1, 1910 TO AUGUST 1, 1911.

Assistant Entomologist's salary	$1,199.97	
Assistant Entomologist's traveling expenses	18.44	
Assistant in Federal inspection	41.65	
Building Machine Shed	385.00	
Clerk and accountant	905.00	
Cuts, etching, etc., for press bulletins and circulars	144.81	
Drawings for report, bulletins, circulars, etc	475.80	
Express and freight	63.80	
Field work	161.62	
Insectary assistant, (field expenses)	177.57	
Insectary chief (field expenses)	115.11	
Insecticides	10.64	
Kerosene for combating grasshoppers	125.89	
Labor	183.00	
Laboratory supplies	81.02	
Lumber	4.45	
Models of insects	15.00	
Nursery inspection	175.55	
Office assistant	69.58	
Office supplies	29.05	
Photos, negatives, prints, etc	40.15	
Printing (bulletins, circulars, reports, etc.)	712.54	
Publications, periodicals, press notices, etc	109.23	
Postage (correspondence, bulletins, report, etc.)	139.00	
Stationery	52.39	
Substitute stenographer	45.00	
Telegrams	15.36	
Telephones	50.00	
Traveling expenses	40.14	
	$5,586.76	
Balance on hand August 1, 1910		$ 32
Credit shown on State Auditor's books carried from end of year 1908		9
Credit nursery inspection		26
Fund		5,00
		$5,58
		5,58
Balance on hand		$

NCIAL STATEMENT,* FISCAL YEAR AUGUST 1, 1911, TO AUGUST 1, 1912.

.....	$ 14.00	
Entomologist's salary	1,466.63	
Entomologist's expenses	19.13	
n Federal inspection	36.72	
ccountant	985.00	
gs, etc., for press bulletins and circulars	38.94	
or report, bulletins, circulars, etc	325.00	
d freight	37.81	
.....	50.36	
ssistant, (field work)	35.46	
hief (field expenses)	5.40	
upplies	62.01	
.....	219.13	
supplies	38.04	
spection	84.83	
ant	53.12	
ies	143.31	
atives, prints, etc	234.60	
ulletins, circulars, etc.)	696.85	
.....	149.72	
.....	100.00	
.....	57.66	
tenographer	99.00	
.....	47.65	
.....	60.00	
xpenses	165.59	
	$5,235.96	
.....		$5,000.00
y inspection		236.25
		$5,236.25
		5,235.96
on hand		$ .29

overing details of above on file in State Auditor's Office.
ent of sums appropriated by the legislature, the aggregate amounts from the State Treasury and balances unexpended, are correct n by the records of this department.

Samuel G. Iverson

State Auditor.

PLATE I

J. E. WOOD, del.

SOME MINNESOTA GRASSHOPPERS

GRASSHOPPERS, AND OTHER INJURIOUS INSECTS OF 1911 AND 1912.

BY F. L. WASHBURN.

GRASSHOPPERS.

In the past two years special work has been done against these pests of agriculture, four men being stationed in the field in 1911 and two in 1912. These men gave their entire attention to this subject. We were in part enabled to do this with a small special appropriation voted by the last legislature for this purpose, but the money so provided was inadequate and we were obliged to use a portion of our State fund to finish the work. The results of these investigations and of practical application of same have been highly gratifying and we feel fully warranted in making the following statements.

SUMMARY.

1. The only thing that saved Minnesota from a plague of Grasshoppers in 1912 was an abundance of rain in May and early June, which may have destroyed many insects directly after hatching, but which, more especially, gave all crops (as well as weeds) a decided stimulus.

2. Given two or more successive dry seasons, and we will again lose many thousands of dollars' worth of crops through the agency of these insects unless farmers in infested districts take prompt and co-operative action along the line of approved methods of control.

3. We have found a successful control method in the following poisonous spray: Sodium Arsenite 3 lbs., water 180 gallons, molasses 1½ gals.; or in smaller proportions, Sodium Arsenite 1 lb., water 60 gals., molasses 2 quarts. The Sodium Arsenite should be

EXPLANATION OF PLATE I.

1. *Orphulella speciosa;* 2. The Differential Locust, *Melanoplus differentialis;* 3. The Sprinkled Locust, *Chloealtis conspersa;* 4. *Chloealtis gladstoni;* 5. The Clear-winged Locust *Camnula pellucida;* 6. The Short-winged Locust, *Stenobothrus curtipennis;* 7. The Pale-green Locust, *Hesperotettix pratensis;* 8. The Clouded Locust, *Encoptolophus sordidus;* 9. *Phaetaltes nebrascensis;* 10. *Melanoplus minor.*

thoroughly dissolved in the water, the molasses added, stirring it in thoroughly. Page 21.

4. Cost: About 30c per acre (50 gals. per acre) for material, figured at the rate of retail price of Arsenite of Soda, 22c per lb.

5. The use of this spray calls for early and concerted action on the part of farmers, and should be applied when hoppers are very young (shortly after hatching) and always before wings are developed. See illustration.

6. Spraying is best done early in the morning. Do not spray just before a rain. Do not delay spraying on account of pressure of other work; delay might mean a loss of from 25 per cent to 90 per cent of the year's crop.

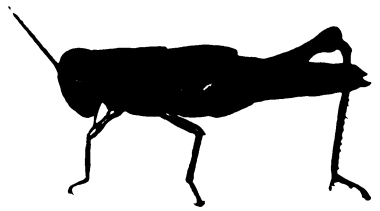


FIG. 1. A very young grasshopper, much enlarged. Spray at this stage or before.

7. Co-operation is the key to success. Grasshoppers might enter a crop of a careful farmer from land owned by a careless neighbor who had taken no action against the pest.

8. Between May 8th and 15th, look for young hoppers hatching in old stubble or in weedy tracts or unused land, in pastures, hayland, and along roadsides. With the above poisonous solution spray a strip from two to four rods wide about the area where they are hatching or over the entire field if not too large. If the infested tract is very extensive, spray a strip about the edges of field from two to four rods wide and several strips through the field. Or spray the poison on a broad strip of planted field, bordering the infested land. The solution at above strength and used as directed will not injure grain or poison stock.

Our observations show that it takes from twenty-four to forty-eight hours for this poison to kill grasshoppers, but the insect is practically paralyzed immediately after partaking of the poisonous dose and eats little or nothing thereafter.

9. Any sprayer which is used ordinarily to distribute paris green in water or any other liquid spray may be used for this work, although a regular field sprayer is best. A combined field and orchard sprayer may be obtained.

10. It should be remembered, in using this spray, that co-operation amongst farmers of a neighborhood is necessary; that early concerted action in spring is important; that while the above solution is not dangerous to plants or stock, if used as directed, it is nevertheless

a poison and if human beings accidentally partook of it, or if stock drank it or ate a large amount of forage thoroughly drenched with it, fatal results might follow. Used as above directed, it is safe. See page 22 for account of our experiment in endeavoring to poison stock with this mixture.

11. For suggestions regarding use of hopperdozers and burning fields, see pages 19, 24, 26.

12. For discussion of cultural methods, protection of gardens, ets., see pages 23, 26, 33.

FIG. 2. Grasshopper conditions in 1910. Crosses indicate presence of grasshoppers; circles, the presence of army worms.

13. Plowing Against Young Grasshoppers: Young hoppers just hatching may be plowed under in a field by beginning on the outside of the field and working toward the center with the plow. Or a strip a few rods wide can be plowed between the valuable crop and a large tract of unplowed land when grasshoppers are hatching. This will form a barrier rather difficult for very young hoppers to cross, thus giving time to prepare other means to use against them. The above

would prove probably only partially effective, and is recommended an emergency only, in order to gain time. See page 26 for merit harrowing.

In 1908 complaints of increasing numbers of native grassl pers began to reach us from Ottertail, Norman, Sherbu Wadena, Anoka and Stearns counties. Clover crops near St. Cl

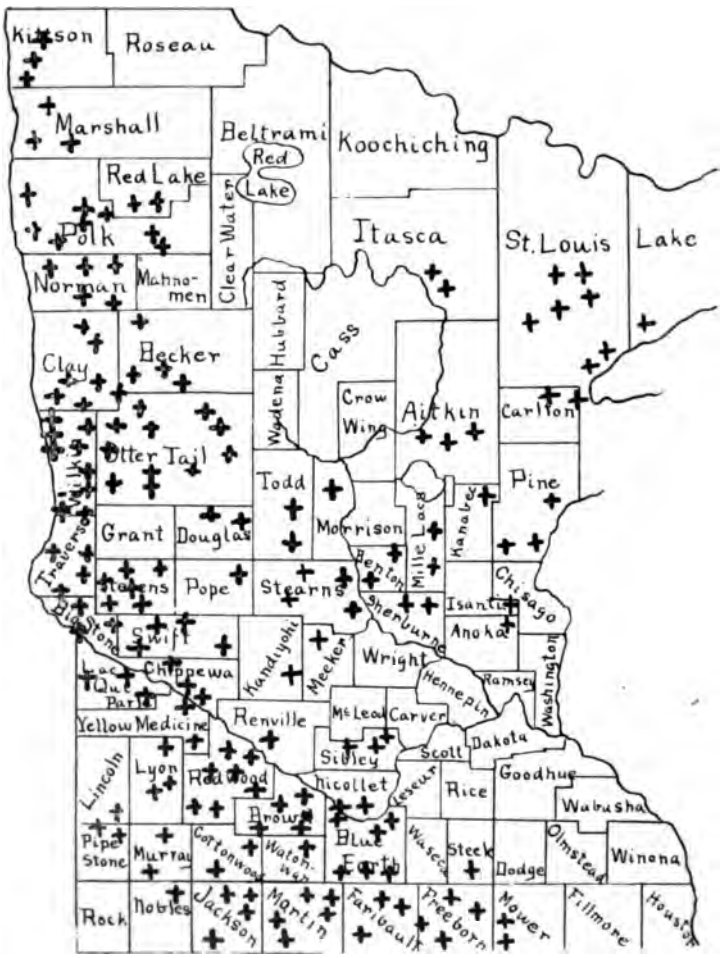


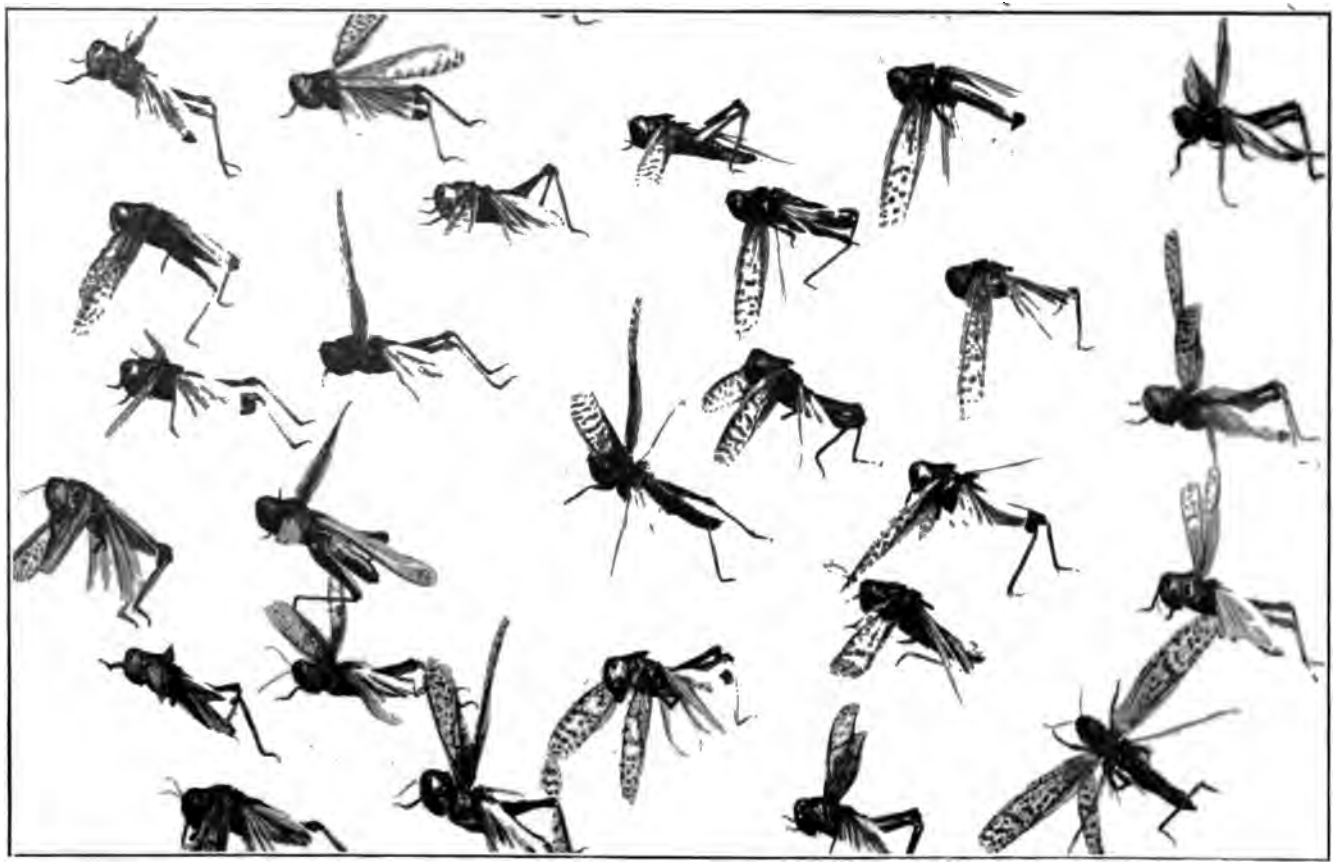
FIG. 3. Grasshopper conditions, 1911. Crosses indicate localities from which many complaints of grasshopper injury were received. Compare with Fig. 2 and note spread of these insects.

tially or entirely destroyed. In other localities it was either clo alfalfa, pasture land or grain which suffered. In 1909 these p were again troublesome and evidently on the increase. Conditi *Clearwater, Sauk* Rapids and South Haven were in that year

so favorable for their multiplication that in 1910 they were
1 more numerous. In that year about two-thirds of our flax
was sacrificed to locusts. In 1911 we experienced the culmina-
of their destructiveness,—the result of the increase of the
preceding years under conditions favorable to these insects.

FIG. 4. Showing portions of State where *M. atlanis* and *M. bivittatus* were most abundant in 1911. Somes.

at year grasshoppers were very bad in various localities in the
ern third of Minnesota from the Canadian border to the Iowa
Many farmers lost from 25 per cent to 95 per cent of their
. During the year 1911 they were also bad in Iowa, Wiscon-
nd other states, and in that year, too, many complaints were



received from districts in the southern half of Minnesota. The outlook for 1912 in the summer of 1911 was serious and Mr. Somes, in charge of this work in the field, predicted an alarming increase if weather conditions favored. Fortunately for us, the spring and early summer of 1912 were very unfavorable to grasshopper ravages and but few reports of injury have reached us during last summer. It must be borne in mind, hovewer, that two or more dry seasons in succession, or even one excessively dry summer, a condition we are quite likely to meet in this state, will encourage the increase of grasshoppers to such an extent that much loss will be again occasioned if farmers are not ready to take concerted and timely action. It is to be hoped that our citizens will not, therefore, be apathetic, doubting and critical of this work until, when the destruction of crops is at its height in midsummer, they feel compelled to call upon the entomologist for help, too late for effective action. This has been too often the case in the past, and July and August have witnessed hundreds of letters in the mail of this office, asking for relief at a time when relief is not possible.

It is not to be understood that the entire grain output of the State has been materially lessened by the ravages of these pests, but individual farmers living in the regions above mentioned have lost from 20 to 90 per cent of their crops and in some cases all of their grain has been destroyed.

The greatest destruction has, in every case, been in proximity to large tracts of land which have been, perhaps, in tillage some years ago, and have been allowed to revert to natural conditions. Such tracts are really the direct cause of all the trouble which we have experienced. It is true we have in Minnesota a grasshopper law which, supposedly, effects the plowing of such dangerous land when infested with grasshopper eggs, but, as a matter of fact, the law is ineffective through faulty wording, and it is utterly impossible for counties to plow this land. For instance, in one township alone in a western county we know of at least 8,000 acres of land which calls for the plow and does not get it. Through the ineffectiveness of this law the owners cannot be forced to plow, and at the rate of $2.50 an acre it would cost this county over $16,000 to take care of reverted land in this single township alone.

Quoting from Mr. Somes' report for 1911:

"We may say that the grasshopper question has been growing more serious each year for several seasons and that during the past summer (1911) the damage was greater and far more widespread than at any time previously since the visitations of the Rocky Mountain Locust. The reports of damage from hoppers came to us from almost all parts of the state and although the

dry winds which prevailed in portions of the state during the summer make it almost impossible to say exactly what percentage of the damage was due to grasshoppers and what to these dry winds, yet to any one visiting as we did all parts of the state, it was very apparent that the grasshoppers' share of the damage was great. The oats, flax, wheat, barley and timothy were seriously damaged and the crop much reduced in both quantity and quality.

Fig. 5. Where *M. differentialis* was abundant and destructive in 1911. Practically confined to southern portion of the State. Somes.

In the southern portion of the state and in parts of the eastern portion the grasshoppers were noted in serious numbers this season (1911) for the first time, which can only mean that the grasshopper area is growing in at least these two directions. This was true not only within the state but in neighboring states, as in Iowa, the Dakotas, Nebraska and southern Wisconsin. According to reports from people living in those places, the grasshoppers also appeared there in numbers so great as to cause more or less alarm. *While it is always* dangerous to attempt prophecy, yet it seems evident that

this widespread occurrence of the grasshoppers in midsummer must result in equally widespread deposition of eggs. We prefer to thus simply present the facts and leave the interpretation of these to others. The facts to which we may call attention are, that we have had grasshoppers in harmful numbers in some parts of the state, and that we will doubtless have them to meet at least in some places during the coming summer. We have called attention to the need of early action against this pest to accomplish any real good. We have also called attention to the need of organized effort or co-operation against this common pest."

We have stated that in practically every instance of serious and widespread grasshopper injury, we have found the original source of the grasshoppers to be reverted or waste land. In this connection we quote again from Mr. Somes' report:

"A discussion of means of reclamation of these infested areas would hardly fall within the province of this report but it must be recalled that although the so-called 'plow law' or 'grasshopper law' is by reason of its wording. practically worthless, yet any law that may be drafted is equally worthless unless rigorously enforced.

A certain tract near Beltrami is very well adapted to illustrate the general conditions in any infested area and may be treated in some detail.

In the above sketch "A" represents a large tract of "reverted land" and the source of infestation from which the grasshoppers will sooner or later spread in all directions. Thus it may be seen that the farms surrounding this tract must suffer. In this case we note the grasshoppers spreading first in great numbers to the tract "B" where they were so thick as to totally cover spots of ground from ten to twenty feet square. Later they spread out to "D", "C", "E", "F", and "G". They were not found in numbers in "I" and "H" probably because these pieces were pasture and the hoppers were there more or less disturbed by the stock. This illustrates the general condition found elsewhere, save that the source is variable in size."

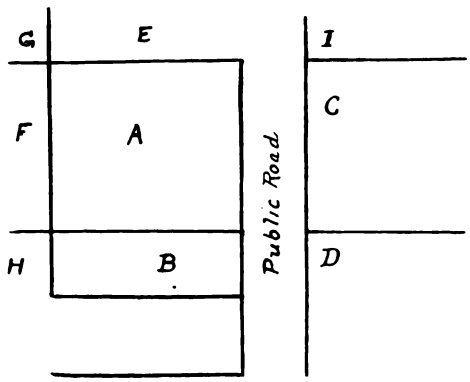


Fig. 6. Diagram showing where grasshoppers start and how they spread. Somes.

The four men in the field in 1911 carried on work along certain definite lines. Headquarters were established at Fergus Falls in the Red River Valley, and there, through the courtesy of city officials, were given a laboratory, and also secured near the city a piece of land for experimentation.

The laboratory work consisted largely of the study of life histories of injurious species, the rearing of parasites; and upon our experimental ground we planted grain crops to test thereon the efficacy and safety of the poison spray referred to at the beginning of this article. We also secured the co-operation of many farmers

of intelligence in the matter of this spraying. We desire to express our appreciation of the many favors shown us by the High School authorities at Fergus Falls, and by other citizens, notably C. R. Wright & Co.

An important feature of the work in 1911 and one which took almost the entire time of the leader, and also a large share of the time of one of the other workers consisted in answering calls of individual farmers who needed advice or encouragement, or both. This has taken much time and much money, as one will readily realize, and we determined in the fall of 1911 that this part of the work would have to be discontinued. We are willing to meet and discuss the question with groups of farmers, when such meetings are called for this purpose, but we find that frequently farmers who had no special occasion for our help, summoned us, although quite indifferent to what we had to say and to our advice. This was not, by any means, always the case, and we believe that, in spite of the large expense occasioned by this variety of work, much good was accomplished by our individual visits.

The attitude of the farmers and citizens generally was one of interest and showed a co-operative spirit; at the same time, many instances were met with which were discouraging. This, we believe, is particularly true among those renting farms, who took the attitude that it was not worth while to make any effort, or that, perhaps, the grasshoppers would not be so bad another year, or they were leaving to go to what seemed to them more promising fields, or they doubted the efficacy of the treatment advised, or they thought, some at least, that the State should bear all expense in treating individual farms. We found criticism and lack of sympathy on the part of real estate dealers, who felt that their business interests were being interfered with by what looked to them like undesirable advertising. In one case, where a hopperdozer with its victims(over a bushel) was displayed in a public street, to show the efficacy of this treatment, interested and misguided citizens who had land for sale in that vicinity ordered the machine and dead hoppers to be removed.

Quoting again from Mr. Somes' report for 1911:

"After about May 20th the calls by mail and by wire from farmers asking advice regarding methods of combating this pest became so numerous that practically all of my time for the greater part of the summer was taken up in replying to these. At times I had as high as thirty calls per day by mail alone. It is needless to remark that the visits entailed in responding to these calls meant almost continuous travel. Our plan, suggested by yourself, was to visit the interested parties and give advice as to methods and especially to urge the *energetic and concerted* action by the men of the community that is necessary to

meet so serious and widespread a pest. In this connection I may say that at times I was forced to take one or more of the men from the field work and place them also at answering these personal calls. We have visited during the past summer (1911) one hundred sixty-one localities and have in this way given advice to approximately one thousand farmers. Thus we have been able to spread a real knowledge of methods of fighting the grasshopper, together with some realization of the problem as a whole throughout a large part of western and southern Minnesota.

In general we may say that we found the farmers very much interested and willing to consider the methods of treatment which we were presenting. There is, however, a noticeable tendency among the farmers, while admitting the serious damage resulting from the grasshoppers, to put off until some future date the actual work against these insects. During the early part of the season many exaggerated reports were published in various newspapers concerning the wholesale destruction of grasshoppers by abnormally cold weather in late Spring and assuring the interested farmers that for "this season" there could be no danger of grasshoppers becoming abundant. It is needless now to call attention to the true conditions resulting during the summer, but it is interesting to note that one of the most seriously affected areas within the whole state—where the grasshoppers were noted in most abundance and the damage to crops was most apparent—was but fifteen miles from the office of one of these papers which had reported the pest as having been exterminated by late frost and snow. The effect of these false prophets was far more serious than might be thought, since farmers deluded by such reports bearing some tinge of authenticity from the fact of publication, neglected to take any action against the pest even in localites where the older methods of attack, such as the "hopperdozer" were well known.

A peculiar attitude of mind was discovered in some cases regarding the expense for labor and materials used in fighting the grasshoppers. It was urged by some, and notably by land owners of some means rather than by the poorer class of farmers who in losing relatively little had lost all, that the State should pay for the work and for materials used in freeing the fields of the farmer from this pest. Since the money available for such ends must come through added taxes a very little consideration usually served to change this attitude. Another peculiarity was noted in the fact that certain farmers after asking for advice would refuse to act upon this advice after your agents had made long trips to reach them. A still worse attitude was encountered in a few cases where mere curiousity had prompted the party to send in a call for a visit from the agent though there were relatively few grasshoppers. The usual justification offered was that "since the State paid the expenses" they felt entitled to the visit although they did not desire and could not utilize any advice which might be given. The loss of time and incurring of considerable expense uselessly was entirely overlooked."

About seventy-nine Orthopterous species were collected and named during 1911, which must not be regarded as representing our entire Orthopterous fauna. Of these species, only a comparatively few were strikingly injurious; namely, the Two-striped Locust, *Melanoplus bivittatus;* the Lesser Migratory Locust, *M. atlanis*, the Red-legged Locust, *M. femur-rubrum*, and the Differential Locust, *M. differentialis*, to which harmful species we may possibly add the Short-winged Locust, *Stenobothrus curtipennis*, and, to a lesser extent, the Clear-winged Locust, *Camnula pellucida*, and the Carolina Locust, *Dissosteira carolina.*

Quoting from Mr. Somes' report for 1911:

"While the Rocky Mountain Locust has been very commonly mentioned in the newspapers this summer, as usual it is merely a case of mistaken identity. ..... One of the most abundant of the species found, however, is *Melanoplus atlanis*, a species based on such slight difference of structure that none but a specialist could positively separate the two. Indeed, from the study of a very large series of this species taken this summer in widely separated localities, it appears that with the wide range or variation found in both there must be doubt as to the validity of specific separation. Thus the public may well be excused for mistaking two species which are in such close relationship as to render them a puzzle to the student of this group. .....

Regarding the seven species listed above we may say that while ordinarily the Tryxalinæ are of little importance, yet we found *Stenobothrus curtipennis* a very serious pest being very numerous and also extremely widespread, occurring at every point where we made collections.

Camnula pellucida was found locally plenty in several places but is not apparently very generally distributed. It is, however, a species which may at times become a very serious pest.

Dissosteira carolina, the familiar Carolina locust, is widely distributed but seldom to be considered actually a pest, being for the most part an insect of roadsides. Late in the season it has been found abundant, however, in cornfields and other dry places and did considerable actual damage.

Melanoplus bivittatus, here including also *M. femoratus*, which we can but consider as a form of this, has been the most seriously injured of the species, from point of numbers and from distribution. It has been the dominant species in most localities where we studied the conditions.

Melanoplus atlanis, "The Lesser Migratory Locust," has been a close second to the preceding species in importance, being nearly as numerous and but the two preceding.

Melanoplus femur-rubrum, the common or "Red-legged Locust," has been found at every point where collections were made but in lesser numbers than the two preceeding.

Melanoplus differentialis, commonly called "The Big Yellow Locust" by the farmers, has been very abundant and very harmful but within a limited area. In general its distribution has been limited on the north by the Minnesota River.

Certain of the *Locustidae* notably *Orchelimum glaberrimum* and *O. agile* may be harmful at times especially in lowlands, while among the *Gryllidae*, the common Cricket, *Gryllus pennsylvanicus* and *Gryllus abbreviatus* are usually present in large numbers, more especially the present year, possibly from the same cause as the Blister beetles, i. e., abundant food in the numerous grasshopper eggs last year. For the same reason *Nemobius* also is abnormally abundant."

In 1912 the Clear-winged Locust was found extremely abundant in portions of Polk and Norman counties, exhibiting a marked increase over conditions in 1911. In early August it was reported as being abundant in the northern part of the state from Dakota to Lake Superior. In the Iron Range it has become perhaps the predominant species, conditions there being especially favorable for its increase. Alfalfa was in many places attacked and ruined by this species.

The following is a list of Orthopterous species collected or reported in the state by field agents in 1911. We are indebted to Prof. Lawrence Bruner for the identification of eight or nine of these species listed:

tix granulatus
tix granulatus var. variegatus
tix hancocki
tix obscurus
ratettix cucullatus
tigidea parvipennis
tettix tricarinatus
phulella speciosa
romorpha viridis
oealtis conspersa
oealtis gladstoni
nobothrus curtipennis
mphocerus clepaydra
eneotettix scudderi
ia obscura
costethus lineatus
phia arcta
phia (tenebrosa) pseudonietana
phia carinata
rtophaga viridifasciata
coptolophus sordidus
nnula pellucida
piscus tuberculatus
piscus rugosus
piscus zapotecus
sosteira carolina
aragemon aequale
aragemon collare
aragemon wyomingianum
stobregma cinctum
nidia fenestralis
cotettix verruculatus
udopomala brachyptera
pochlora alba
perotettix pratensis
perotettix speciosus
istocerca alutacea
lanoplus scudderi
lanoplus dawsoni
lanoplus blatchleyi
lanoplus atlanis
Melanoplus spretus
Melanoplus femur-rubrum
Melanoplus gladstoni
Melanoplus extremus
Melanoplus angustipennis
Melanoplus packardi
Melanoplus luridus
Melanoplus collinus
Melanoplus differentialis
Melanoplus infantilis
Melanoplus femoratus
Melanoplus bivittatus
Melanoplus minor
Phaetaliotes nebrascensis
Scudderia curvicauda
Scudderia furcata
Amblycorypha oblongifolia
Conocephalus ensiger
Conocephalus nebrascensis
Orchelimum glaberrimum
Orchelimum longipennis
Orchelimum nigripes
Orchelimum agile
Xiphidium fasciatum
Xiphidium saltans
Xiphidium nigropleura
Xiphidium strictum
Xiphidium brevipenne
Xiphidium ensiferum
Ceuthophilus blatchleyi
Ceuthophilus devius
Nemobius fasciatus
Nemobius canus
Nemobius carolinus
Gryllus pennsylvanicus
Gryllus abbreviatus
Oecanthus fasciatus
Oecanthus quadripunctatus
Oecanthus niveus
Anaxipha exigua

This list has been added to during the current year (1912) by following species reported by Mr. Somes:

Nomotettix parvus, of state-wide occurrence
Chloealtis abdominalis
Tettix luggeri
Tettix ornatus
Melanoplus fasciatus
Melanoplus impiger
Trimerotropis citrina

Melanoplus foedus
Hippiscus haldemani
Spharagemon bolli
Podisma variegata, extremely rare, taken near Duluth, and a few other forms, some of which are not yet identified.

A popular key to the four most destructive species in Minnesota is here appended by means of which one should be able to tell, if he desired, to what species any one of the four which he had under consideration belonged. They all belong to the genus *Melanoplus* and are all characterized by a small conical spine between the front pair of legs.

LARGE BULKY FORMS; "HIND LEGS" NOT RED.

Two light colored stripes along the back (along upper edge of wing cover); body color variable from brownish to greenish yellow; "hind legs" yellow or partly dark but not red. This is known as the "Two Striped Locust" or sometimes as the "Yellow Striped Locust." Its scientific name is *Melanoplus bivittatus*.

As large or even larger; general color yellowish or greenish yellow, without the two light colored stripes along the back; "hind legs" yellow, never red. This is known as the "Clumsy Locust" or the "Lubberly Locust." Its scientific name is *Melanoplus differentialis*.

MEDIUM SIZED AND MORE SLENDER; "HIND LEGS" NEARLY ALWAYS RED.

General color tan or yellowish brown; larger part of "hind leg" has two distinct dark bars on the outer face; tip of abdomen in males, always with a distinct notch. This is the "Lesser Migratory Locust" and is very closely related to the "Rocky Mountain Locust." Its scientific name is *Melanoplus atlanis*.

General color reddish brown, without distinct dark bars on hind legs; usually smaller and shorter winged than the above; This is the "Red-legged Locust" or "Garden Locust." Its scientific name is *Melanoplus femur-rubrum*.

In the above list it will be noted that Mr. Somes includes the Rocky Mountain Locust, *M. spretus*, basing his statement upon the collection of one specimen. We figure the specimen herewith. While it has the ear-marks of the so-called species *spretus*, we are inclined to think that in its genital plates it resembles *atlanis* quite as much as it does *spretus*. At any rate, the finding of this one isolated example in the midst of so many other species, *atlanis* among the rest, would appear to throw doubt upon the validity of *spretus* as a species.

A noteworthy fact in connection with our operations in 1911 was the extreme abundance of *M. bivittatus*, which easily led in numbers of individuals in almost every infested locality. From be

ing secondary in economic importance three years ago, it took the lead in that year as being the most abundant of injurious forms. As a fact accessory to the abundance of grasshoppers in Minnesota in 1909, 1910 and 1911, it is to be remarked that a Meloid beetle, *Macrobasis unicolor*, and possibly one other species, commonly known as Blister Beetles, were extremely abundant and injurious in our state during the early part of 1911. This, without question, is to be ascribed to the great abundance of grasshoppers upon the eggs of which the young of these beetles feed. See page 44.

Fig. 10. Rocky Mountain Locust, (*M. spretus*)♀, showing genital plates of male Collected in 1911. Somes.

Ecological Notes:

From Mr. Somes' report for 1911 and Mr. Howard's for 1912, the following facts bearing upon life histories are deduced.

Mr. Somes noted *Melanoplus bivittatus* drilling in hard packed soil of roadbeds and on one occasion at Crookston one was watched for some time busily drilling in a hard cinder walk in a city park. All species appear to prefer dry and rather firm soil. The *Oedipodinae* will deposit in much softer or more friable soil than the *Acrididae*. In examining various localities for eggs this fall, they were found very abundant in a piece of land which had been plowed in July (the "nests" averaged 9 or 10 per sq. yd.) so that the statement so often made—that they will not oviposit in plowed land—is untrue. A number of counts made in corn land showed relatively few egg masses and these for the most part only at the edges of the fields. In stubble, especially in flax, they were most plenty, running as high in one case as 14 masses to one square yard.

The fact that eggs are deposited in low ground that may be under water in the spring does not necessarily mean that these eggs are doomed. Indeed it has been noted in portions of the Red River Valley that young hoppers emerge in July instead of May from some spots where water had been standing through the early part of

Fig. 11. Roadway and ditch showing character of ground where egg laying takes place. Normal habit at of three destructive locusts, *M. atlanis*, *M. bivittatus* and *M. femur-rubrum*. C. W. Howard.

the season. Thus the development was merely delayed—although of course we have no data on the percentage of the eggs that may have been destroyed by rotting or otherwise failed to hatch.

We have noted in the field throughout the summer young of various instars at all times. This may be because of somewhat sim-

Fig. 12. Natural breeding ground. The insects lay their eggs in stubble, also side of road, and even in road itself. C. W. Howard.

ilar retarding of development due to moisture or conditions of exposure.

Certain facts noted in regard to egg-laying and mating deserve consideration. As a result of very numerous dissections and counting of eggs in the bodies of female grasshoppers, it seems probable that more than one egg mass is deposited. It was noted that in case of females infested with fly larvæ (see under discussion of parasites) there were notably fewer eggs than normal. Blatchley, (Orthop. of Ind. p. 145) speaking of grasshoppers affected by these fly larvæ says, "they never mate"—this we (Somes) rather doubt, as we have found females so infested and yet having 24 to 40 eggs in the ovary.

The old figure of Riley showing that in oviposition the abdomen of the female is thrust downward and somewhat forward is evidently open to criticism, for in addition to Cooley's contribution on this point, Howard last summer observed in M. bivittatus a decided modification of the method as described by Riley. In other words, the egg pocket does not point directly down, or downward and forward, necessarily but may be directed somewhat backward, even to such an extent as to be nearly parallel with the surface. See Fig. 12a. That this fact has a definite bearing on the old theory of the advantages of "turning over the pockets with the plow" is self-evident.

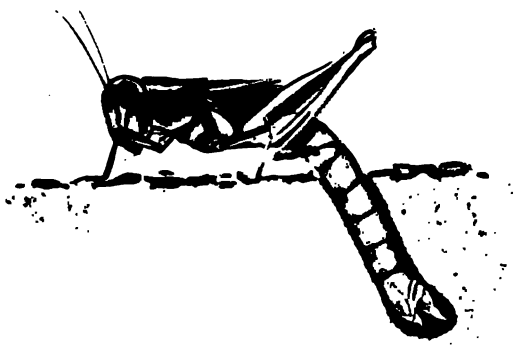


Fig. 12a. *M. bivittatus* ovipositing. Wings worn and frayed. C. W. Howard.

To prove or disprove certain statements of farmers as well as investigators to the effect that amongst destructive locusts, the females far outnumber the males, counts were made at different localities with the following results. Each count is made up of the number caught in ten sweeps of the net where the hoppers occurred.

LOCALITY.	FEMALE.	MALE	REMARKS.
Meadow	6	5	Includes all instars
Weed land	17	10	ous species.
Roadside	11	12	Many in 3d and 4th
Pasture	10	8	
Pasture	16	12	
Oat field, Edge	11	10	
Oat field, 10-12 rods out in field	6	5	
Oatfield 14-16 rods in field	4	5	
Edge of oats along corn field	20	14	Large adult M. b
Edge of oats along corn field	15	20	Large adult M. b
Totals	116	101	

Further "sweepings" were made later in other localit comparison of the two sexes made up of the number ca twenty sweeps is as follows:

LOCALITY.	FEMALES.
Reber's E. field Foxhome	31
Flax field E. of French edge of field	17
Ten rods out in same field	11
Weed patch two miles W. of Fergus Falls	19
Totals	78
June 26; Flats South of Foxhome, 20 sweeps of net	27

It is probable from the above evidence that the propo male and female in the species captured is very nearly equal.

Mr. Howard (1912) made some tests with the three injurious forms to determine what plants were eaten by hoppers. They may, of course, be regarded as general feed will turn to anything edible if forced to. While grai different varieties of grasses are preferred, the following shrubs and trees attract them or not as indicated.

Mustard	eaten	greedily
Sunflower	"	somewhat
Chenopodium	"	greedily
Dandelion	"	readily
White Clover	"	readily
Docks (Numex)	"	slightly
Scotch Thistle	"	slightly
Large leaved Dogwood	"	readily
Onions	"	readily
Radish	"	slightly
Beets	"	readily
Peas	"	slightly
Alfalfa	"	greedily
Wild Parsnips	"	greedily
Mushrooms	"	readily
Burdock	"	slightly

Amaranthus	"	readily
Willow	"	readily
Boxelder	"	readily
Elm	"	readily
Lilac	"	slightly
Soft Maple	not	eaten

Methods of Control.

While experimenting with a poison spray we have at the same time urged farmers to use the old-time hopperdozer, personally showing them in many cases how to make the same, and have also been advocating late fall plowing, poison baits in gardens, but par-

Fig. 13. Hopperdozer in action.

ticularly to protect the latter, the placing of flocks of turkeys, which not only have an insatiable appetite for grasshoppers, but are a profitable adjunct upon any farm. Many farmers believe that a grasshopper striking the drenched sheet at the back of the hopperdozer, or falling into the pan and then getting out, is not killed, and we have been in the habit of assuring them that the slightest drop of oil upon an insect of this kind will kill, and that each one of these grasshoppers is doomed. Mr. Somes' observations this summer would seem to indicate that that statement must also be qualified, and that it must be acknowledged that although short-winged forms or wingless stages that are wet with the oil undoubtedly per-

ish, inasmuch as the oil reaches the spiracles, many long-win forms do not die because of the protection to the spiracles affor by the wings. This shows the importance of the early use of hopperdozer, before wings are attained.

We have not advised the burning over of fields alive with yo hoppers, believing the same to be dangerous and of questiona abiliay in a country where a hay crop is an important feature. emergency cases, however, it may well be resorted to. We enco age co-operation, and we have especially advised action agai

Fig. 14. A crude and cheap Hopperdozer.

grasshoppers, and vigorous action, when they first appear, even i interferes with other farm work, for we find that whatever plan follow as regards this pest, that they are much more easily handl as would be expected, when they are young, than when they h attained their wings.

Our field workers reported only partial success with poison ba represented by poison bran mash and Criddle Mixture, but have the course of their work, hit upon a rather unique poison which t have courteously called the "Minnesota Mixture." Finding t *arsenite of soda* used as a spray, and combined with a little molas

was very effective against grasshoppers, they substituted this for the Paris Green used in making the Criddle Mixture. They used the following formula:

Sodium arsenite 1 pound; horse manure 120 to 150 pounds; cheap molasses 1 pint. The arsenite of soda was dissolved in the water, then added to the manure, stirring it well.

This is cheaper than the Criddle Mixture and can be used in the same way. It forms a very attractive bait for grasshoppers. It was tested upon poultry to see whether these animals, in picking grain from such material, would be injured. Two roosters were fed upon it for some time with no bad results. Incidentally, it may be said that flies are attracted by this compound in enormous quantities, and are killed by the hundreds in feeding upon it. After this mixture had been exposed in the experiment with the roosters for a day over a quart of dead flies was found on the floor of the shed containing the poultry. This observation might be of value to those who are making a fight against the house fly, and it has been suggested that spraying piles of horse manure exposed in barns and livery stables with a solution of eight pounds of sodium arsenite in about twenty gallons of water, to which has been added about a half pint of molasses, would be a useful measure against the house fly.

Our most prominent work has been done with a poison spray. Aware of the success of arsenite of soda used as a spray in South Africa, it was decided to try it in Minnesota, thinking its use might be applicable to large tracts in the Red River Valley which call for treatment. We found that 3 pounds of commercial arsenite of soda, 1½ gallons of molasses, in 180 gallons of water, made a mixture which was fatal to hoppers and did not in any way injure crops. We used, in most of our experiments, field sprayers which covered 23 feet at one time. Approximately 50 gallons were applied to the acre at a cost of about 30c for material, this estimate based upon the retail price of arsenite, namely, 22c per pound. The location of water supply is an important feature in the cost of labor. Further, we believe that when vegetation is quite rank an acre would call for something more than 50 gallons. This poison did not kill immediately,—from 24 to 36 hours elapsing before the insect gave up the ghost, but it is to be noted that a partial paralysis was the immediate result of partaking of the poison. The insect was immediately made sick and ate nothing.

We received from various farmers congratulations upon this method, and statements of their success in using it.

Of course, the question at once occurs to the practical farmer as to whether this is dangerous to stock. We have made tests along this line, and while it must be remembered that any poison is detrimental and frequently fatal if taken in too large amounts, we feel convinced from our experiment, that, as ordinarily used by a farmer bearing the above fact in mind, no bad results will happen. A Holstein bull was fed with forage poisoned with this spray in the above proportions, being fed about 15 pounds of this each day for ten days, and showed absolutely no symptoms of poisoning.

Fig. 15. Our sprayer applying Arsenite of Soda.

As further proof that this compound if handled rightly will not affect stock we give here details of a final and to us convincing experiment: On May 20th, 1912, we sprayed an enclosed small pasture containing 1-10 of an acre with the above described arsenite of soda spray, applying it at the rate of 60 gallons to the acre. A young heifer purchased for the experiment was turned into the enclosure that evening, and (since she had been stall-fed for several days) she immediately ate heartily of the poisoned forage. May 21st, no bad effect noticeable. Heavy rain on night of 21st, probably washing a large proportion of the poison from the grass. May 22d, heifer in good condition apparently; bowels quite loose but doubtless due to abundance of grass feed. Heifer was then placed *on untreated* grass outside of lot for three days, during all of which

e she appeared in perfect condition. On 26th, sprayed enclosed
ı again, same proportions and amount as above. Heifer turned
n treated grass one hour after spraying. A heavy rain occur-
: a few hours thereafter, we again sprayed the grass as above,
heifer browsing on it immediately. For two and one-half days
was confined on this poisoned pasture, receiving no other food,
r which period she was placed on outside grass and carefully
:hed for five days. No unpleasant symptoms of any kind ap-
'ed. At time of experiment she was within a month or two of
ing and was sold to a party desiring a milch cow. At date of

Fig. 16. Another view of sprayer.

ing she is in fine condition. A week after she was taken from
)asture a pet horse was turned in and allowed to feed there for
a day without the slightest effect upon the animal.

As regards fall plowing it is possible it will be necessary to
ify recommendations in that connection, and the advice that we
: given to this end in years gone by may represent an example
ıe general acceptance and promulgation of certain remedies, the
oughness of which has not been properly tested,.

n the first place, farmers for the most part will not plow in the
fall. They have large tracts of land to handle, and as a rule,
that they must begin their plowing immediately after the crop
f the ground. This is before egg-laying takes place. Our field
ıt, Mr. Somes, doubts the efficacy of the plow unless it is fol-

lowed by the harrow. He claims that more real good results from cultivation with a harrow, since that has a tendency to break up the egg masses and expose the eggs to the effects of bleaching and drying, and rendering them more easily accessible to their natural enemies. He further claims that at the time the young hatch the enveloping capsule has become soft and jelly-ilke, and that the young grasshopper may easily push up through that toward the surface in cases where the capsules are inverted by the plow. He does not believe that the alternate freezing and thawing of the eggs causes the death of the same, since, being close to the surface, they may be subjected to that in Minnesota every season. In fact he exposed to alternate freezing and thawing last winter newly hatched grasshoppers, twenty, according to his report, having been frozen and thawed twice with no mortality, except in the case of one individual, which probably perished through rough handling. In spite of his belief, as here cited, we still think that turning the eggs under deeply must materially lessen the number of grasshoppers which would naturally emerge the following season, and, plowing being in accord with farm practice, shall continue to recommend it until we know of something better.

Since special attention was given by the field workers to practical method of control, and since our recommendations are based upon this practical work, it seems advisable at this point to quote fully from the report submitted to this office detailing the work done in the field in 1911 under Mr. Somes' direction:

"The Hopperdozer, although widely known is so generally confused with the "tar pans" of the early days and with various other more or less similar devices that a detailed description of the hopperdozer as used in Minnesota may be of some value here. We may say that we have found this "dozer", when well designed and when used at the proper time of year, to be a cheap and effective method of exterminating grasshoppers and worthy of more general use. The essential part of a hopperdozer is a pan or trough of galvanized or sheet iron, to the back and ends of which is fixed a light frame of wood or iron extending vertically from 24 to 36 inches. This frame is to be covered with cloth. The pan is mounted upon a wooden frame which is dragged upon "skids" by two horses hitched to bars extending from the ends of the frame. The pans, being made usually of galvanized iron, are commonly made sixteen feet long, twenty inches wide and four inches deep since this size has proved very handy to use and can be made economically and without waste of material. On rough or hilly fields, however, we found it advisable to use pans eight feet in length to better follow the rough surface. We have found it advisable to fix several cross partitions of metal in the pan to lessen the waste from splashing and to brace the pan. We have advised the use of cloth for the vertical wing in preference to metal, largely because this material is less expensive and is very considerably lighter, which latter factor is of considerable importance as may be grasped when we recall the fact that the "dozer" is often to be dragged through fields of young and growing grain. We may add further that a wing of some soft cloth is in fact more effective than one of metal or even of oil-cloth, although this may not be always apparent to the farmer. Our observa-

ions in the field, which were later confirmed by extended laboratory tests, onvinced us that a very high percentage of the young "hoppers" which clus- er upon this cloth wing become covered with kerosene and die within a short ime although they may hop from the wing and apparently escape. The fol- owing is taken from Mr. Stoner's notes at the conclusion of a long series of ex- eriments and observations testing the effect of kerosene in small quantities pplied to the bodies of young grasshoppers and the effect of throwing the hoppers" lightly against a cloth screen wet with kerosene: "These experi- ents would seem to substantitate the statement that "even if a hopper merely its the canvas back of the hopperdozer, this canvas being well saturated with erosene, the hopper will be killed."

In use the pan is filled about half full of water to which is added from ne to two quarts of kerosene. The "wing" is then drenched with kerosene nd the hopperdozer is dragged through the fields. Grasshoppers rising be- fore this "dozer" strike against the "wing" or fall into the pan, in either case becoming wet with the kerosene which kills them in a very few minutes. The time of action with the hopperdozer, as with all other methods of control is very important. The best results can only be obtained if the "dozers" are used early in the season, that is, from the middle of May to the middle of June. At that time the young grasshoppers, not having developed wings, cannot fly over the wings and escape as many of them are sure to do when the use of the ap- paratus is delayed until late in summer. The cost of the "dozers" made as above, is very low. During the past summer they have been made throughout

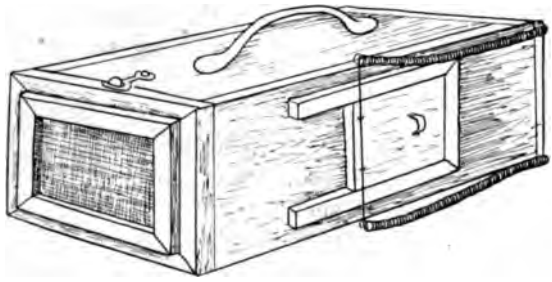


Fig. 17. A convenient grasshopper collecting box, used in field. C. W. Howard.

the Red River Valley at prices ranging from five dollars to eight or nine for the sixteen foot size. It is not necessary to use kerosene of a high grade, in fact in this case the cheapest is the best and grades of oil ranging from seven to ten cents per gallon (at the supply tanks) were found perfectly satisfactory.

As has been said, this device should be used early, practically the only test of time being that the grasshoppers must be able to jump high enough to fall into the pan and this they are able to do within a surprisingly short time after their first appearance.

In cases where fields adjoin large tracts of unused lands which are badly infested with grasshoppers, we found it possible to restrain these young hop- pers within the unused land by plowing a strip two or three rods wide between the edge of the infested area and the cultivated area. This is of course merely emporary relief but in cases when the young hoppers are beginning to swarm ut of such areas and into the young grain, while still too small to permit of he effective use of the "dozer". Young hoppers traveling as they do only by opping, pass over such barriers only with the greatest difficulty, and in fact ery few passed over such plowed strips when used early in the season. It is vident that the supply of hoppers within the infested area is in no way di- minished by this and that unless some means of exterminating them there be pplied they will presently pour out upon the fields in full force.

The plow has been said to be one of the most efficient tools to use against rasshoppers and while *there is* much truth in the statement, yet like many

others, it needs some qualification. Some of the causes given for this value from the plow are that this turns the eggs up and exposes them to the weather, by which is usually understood to the effects of "freeze and thaw." It is, however, extremely doubtful if this freeze and thaw have any bad effects upon the eggs. In the first place they are deposited so near the surface as to be always subjected to these alternations, even if left untouched. In a climate like that of Minnesota where the soil is frozen for long periods to a depth of several feet, the result of displacing grasshopper eggs from a depth of less than two inches to the surface certainly cannot subject them to very different conditions from normal. Apparently the real good resulting from cultivation lies in the breaking up of the egg masses and thus exposing the eggs not to freeze and thaw but to the effects of bleaching and drying in part, and in rendering them more easily carried away by such natural forces as running water, etc., than when protected by the earth blanket in which they were placed. With this thought in mind, the harrow suggests itself as an agent of equal importance to the plow. It has been argued that the plow "upends" the egg mass and that the young hatching are unable to penetrate the "capsule" and so perish. Without regard to the experiments upon which this idea was based, we must here take note of the fact that in natural conditions the "capsule" having been subjected to the varied agencies of the weather, has become, by the time of hatching, a soft jelly-like consistency that certainly could offer little resistance to a young grasshopper. Another theory has been that by deep plowing late in the fall the eggs are turned under to a depth so great that the young hoppers must perish before reaching the surface. While there may be something in this theory, it is evident that conditions must vary widely with the nature of the soil and with the amount of subsequent moisture, etc. Under some conditions the soil may not be sufficiently compact to offer any serious obstacle to the young hopper. Furthermore, we have been informed by observers that after trying this plan and plowing even as deep as seven inches, they have observed young hoppers emerging from the ground the next season, the only apparent result being that hatching was delayed somewhat. Taken all in all we must confess that at the present time we feel that the real value in cultural work against grasshoppers lies in breaking up the egg mass, and hence the plow, unless followed by the harrow, is of less real value than we have thought. Certain practical reasons which need not be here discussed tend to prevent late fall plowing but it is evident that even though early plowing is necessary and customary late harrowing may yet act to good advantage both as to the eggs and as to the soil itself. Spring plowing to be of value must be done just at the time when the eggs are hatching and to be of most value should be followed by the harrow. In fact the harrow should be used in spring on all lands that were plowed in the fall and should be used at the time when the young are just emerging from the eggs

The plan of burning off large tracts to kill young locusts has been tried in many places with somewhat varying reports. In any case there is more or less danger of damage to the hay crop when the burning is applied late enough to be of any real benefit. Often there is also danger of losing control of the fire itself unless great care is taken. From the fact that grasshoppers are not so abundant in raw prairie as appears to be generally thought the burning over of wild hay land is not usually of much real value. In burning off the reverted areas and stubble where the greatest numbers of the young hopopers are to be found, it is frequently best to scatter straw over the area and burn this. * *

While the necessity for action early in the season has already been mentioned in connection with various methods of control, it is a matter of such prime importance that it may be treated again even though it may be in part a repetition. Among the reasons for this early action we may note first the fact that then the young hoppers are wingless and can travel only by hopping. They are thus more easily caught. Another fact is that at first they are much more gregarious and tend to cluster together in masses, while later in the season they scatter widely and any method of killing must be less effective than before. The nature of the vegetation offers another reason for early action, since then the plants, whether weed or crop, are low and do not interfere with *control methods*. For instance in early May it is easy to use a hopperdozer

since grain is low enough and "springs" enough to suffer no damage from the dragging of the dozer through the fields. At the same time there is not enough of the vegetation to cover up the grasshoppers and allow the dozer to pass over them without catching them as is the case later in the season. On the other hand, in using the sodium arsenite, while the grain is young, and the stems short, it spreads more uniformly on the vegetation. Also at that time the hoppers feeding as they do in solid masses are affected in proportionately greater numbers than later when scattered. The hoppers traveling more slowly and more steadily than the adults must feed continuously on the poison-zone and are more certain to eat enough poison to kill. The other advantages in methods of applying poison early, from the fact that at that time (and then only) can large fields be protected by spraying relatively few acres about the borders, has already been treated. While any of the methods described may be used later in the season it is evident that they cannot be as effective at any other time than when the grasshoppers are very young. Every week's delay after that time decreases the efficiency of any method of killing. When one sees, as I have frequently seen, whole fields totally destroyed by the hoppers, it must be admitted that there can be no work on the farm more important in the month of May, than earnest and intelligent work against this pest at a time when the work will be of most value. The need of co-operation is of course imperative but co-operation depends largely upon initiative and in every community there must be leaders who may take up the work and by their efforts sow the seeds of a community spirit that may result in general action against this common enemy. At the same time it must be remembered that the greater part of the real damage done by the grasshoppers is early in the season and each one of the leaders who is applying the various control methods is preventing a large part of the loss he would suffer otherwise, even though the others in his community do not co-operate with him. There is a real benefit to him, since the harm that may come later in the season must be thus lessened.

One of the principal objects of the summer's work is to plan if possible, a method of control which would be at once more effective and more economical than the use of the hopperdozer. With this in view, certain tests with poisons were planned. It was found that Paris Green, either in dry or liquid form, was not very satisfactory. Certain experiments with Arsenite of Sodium which had been carried out by the Entomologist during the previous year seemed to indicate that this poison was worthy of further trial. Reports upon the use of this poison against locusts in S. Africa were also highly commendatory, so it was determined to give some time to experiments with this compound. Most of our tests were made in small enclosed plats measuring two and a half by four feet, thus giving a definite area of ten square feet. Our first trials showed that the poison was satisfactory as regards killing the insects, although we were surprised to find that death did not occur until twenty-four to thirty-six hours after feeding. We noted, however, that the poison took effect within a few minutes and the grasshoppers ceased feeding, the hind legs became helpless and the insect, although alive for a considerable time, gave every indication of being very "sick." The first trials were made with a rather crude preparation of white arsenic and "sal-soda" boiled together but as this was found to vary somewhat in effect, we tried the soluble salt, Commercial Arsenite of Soda, which was found more effective, more uniform and much cheaper than the former. The formulæ used in S. Africa were found to be too strong for use here, since the grain or other vegetation was severely "burned" by the solution. Gradually reducing the proportion of "Arsenite" it was found that the most satisfactory solution was made by using four ounces of the "Arsenite" to fifteen gallons of water. This gave a spray which killed the grasshoppers without damage to the vegetation upon which it was placed. It is evident that any excess of poison must be wasted.

In the following table the solution in each case was made up of water, 15 gallons and molasses, 1 pint. The varying amounts of arsenite being shown in the table:

STRENGTH	EFFECT ON GRAIN	EFFECT ON HOPPERS
2 oz. Arsenite	No effect shown	45 dead; 4 "sick"
4 oz. "	No effect shown	49 dead; 5 alive
6 oz. "	Tips of leaves burned	64 dead; 4 "sick"; 5 alive
8 oz. "	Grain burned badly	51 dead; 5 alive

A stronger formula gave the following results.

5 lbs. Arsenite 1 qt. molasses 50 gals. water	Grain killed	206 dead; 11 alive

In the S. African experiments, the arsenical spray was found most effective when sweetened with treacle or molasses, hence we added molasses to our solution with very good results. Indeed we found the molasses valuable in more ways than one, since aside from rendering the solution more attractive to the grasshoppers, it serves to hold the poison on the plant. After once drying upon the plant the molasses is not readily washed off even by heavy rains and merely softens to sticky masses which drying again still hold the included poison.

Our working formulae may be given as follows (the formula is expressed in three different quantities for more ready use in sprayers of various sizes).

FOR WHEAT, OATS, BARLEY, RYE OR FLAX.

Arsenite of Sodium.....	4 ounces	1 lb.	3 lbs.
Water	15 gallons	60 gals.	180 gals.
Molasses	1 pint	2 qts.	1½ gals.

The Sodium Arsenite, which is a whitish powder, should be added to the water in small amounts and thoroughly dissolved before the molasses is stirred in.

This solution may be applied by any sprayer which is intended to use liquid poisons. Certain features, however, tend toward economy in operation as well as toward most effective results. We have found the best results when using spray at the rate of about fifty gallons to the acre. It is evident therefore that with small sprayers of fifty gallons, capacity or less there must always be a considerable item of waste of time from the frequent filling required. Another point is that the area passed over should be thoroughly covered and to do this the cones of spray must meet at the base, i. e., the nozzles must be so arranged that the whole strip may be covered. This is impossible or at least impracticable with most types of the so-called "Potato Sprayer" since in most of these the nozzles are arranged to spray the rows and usually leave the space between unsprayed.

Our field tests were conducted with large sprayers having a tank capacity of 165 gallons working by compressed air and having extension bars permitting us to spray a strip twenty-three feet wide at a time. On the extension bars were fifteen nozzles so placed as to thoroughly cover the strip. With such machines and an ordinary thresher tank wagon for hauling water we have been able to cover fields of eighty acres in one day.

After our preliminary tests in the test plats previously mentioned we began a series of tests upon a large scale by spraying fields of from twenty to eighty acres of various crops which we found to be badly infested with grasshoppers. The result shown in one or two representative fields may be of interest. On June 24th, Mr. Tanquary sprayed a field of 22 acres of wheat near Beltrami, using the formula given above. Two days later this field was carefully examined and counts made to determine the number of dead hoppers. In order to secure an idea as to the whole field these counts were made in several widely separated parts of the field. The number of dead hoppers found ranged from 30 to nearly 200 in spots ten feet square. To estimate the total number in the field the following plan was used. After several trials to secure uniformity it was determined by count that with the relative proportion of nymphs and adults present it took 370 grasshoppers to make one pint. Averaging results from the various spots counted it was found that the average *for the field was* 2 1-2 bushels of dead grasshoppers per acre of over fifty *bushels to the whole* field as a result of one treatment.

The following commendatory extracts are from letters received by the offices or from articles in newspapers. They serve to show the opinion of men who have tried this method of control against the grasshoppers.

(Morris, Minn., Tribune, Aug. 15, 1911.)

"Kill the Hoppers. Save crops by spraying with Sodium Arsenite. J. J. Gaffney is convinced that he saved his flax crop from the hoppers last week by the early application of a solution of Sodium Arsenite. After Mr. Gaffney had cut his wheat he noticed that the hoppers were very thick in his flax, and last Wednesday had decided to cut it while it was still green when he heard of the sodium arsenite treatment. He procured a sprayer and made the solution and went to work. The whole field was sprayed at a cost of about fifty cents an acre, and the next day the field was found covered with thousands of dead or nearly dead hoppers. Since then there are very few hoppers in the field. Mr. Gaffney is satisfied that his investment of 50 cents an acre saved his fine flax crop."

Morris, Minn., Aug. 28, 1911.

".....I am satisfied that in the Sodium Arsenite treatment we have the hopper problem pretty well solved for next year."

Yours truly,
(Signed) A. G. MARKS.

Extract of a personal letter. See reference to Mr. Marks' use of the Arsenite against hoppers in corn.

Beardsley, Minn., Aug. 9, 1911.

"Dear Sir:—In compliance with your request some weeks ago, when you were here looking after the 'grasshopper situation.' Will say that we have found the sodium arsenite preparation a very good exterminator, considering the way in which we have had to use it. All we had to use was a crude sprinkler that was made by our tinner; but it seemed to 'layout' quite a high percentage of the hoppers."....

Yours very respectfully,
(Signed) AM. M. MORONEY.

In this, as in all control methods, the proper time for action is an element which must not be overlooked. The best results can be obtained by spraying early in the season, i. e., from about the middle of May to the middle of June, just as with the hopperdozer. Action at this time is best for several reasons. At that time the young hoppers are feeding steadily and move in greater numbers than after the wings have developed, and since they cannot fly it is easier to place the poison where they must eat it. When used at this time of the season it is possible to protect large tracts of land by spraying relatively few acres. For instance, in case a field not badly infested with grasshoppers adjoins a tract which is swarming with young hoppers these may be killed as they pass into the cultivated field by spraying a strip two or three rods wide along the edge of this field, through which "poison zone" the young grasshoppers must feed to reach the crop. In case a field is badly infested or to treat a tract of "reverted land" or other source of hoppers the whole area need not be sprayed but by spraying strips across the area in two directions, "checker board fashion," the poison may be so generally scattered as to be effective and yet the actual acreage sprayed is but half or less than half of the area. (There is reason to doubt the real efficacy of the "checker board" spraying, unless the unsprayed squares are very small.—F. L. W.)

In our formula given above, we made no mention of corn for the reason that we have found no practicable method of spraying corn. With this crop the damage by grasshoppers is normally late in the season when the corn is too tall to be sprayed. We are inclined to believe that the best way to protect corn from the grasshoppers is by killing the grasshopper early in the season while on small grains. At my suggestion, Mr. A. G. Marks of Marshall tried the following plan and reports gratifying results. His corn field adjoined a field of oats in which the grasshoppers were so thick that they had utterly ruined the crop and he feared that upon cutting the oats these hoppers would attack the corn. I suggested that he spray a rather wide strip of the oats—

five rods or so—with Arsenite of Sodium and leave this uncut as a "bait strip." After acting as above, Mr. Marks examined the corn field and reported that he saw numerous dead hoppers "even as far as five rods into the corn from the spray," and in the poisoned strip he noted many dead and many "sick."

While in some cases we found that the spray at the strength given above had a tendency to burn the tips of the leaves somewhat, this was neither general nor serious, and in all cases the grain had normal color a week or so later even though apparently somewhat burned immediately after spraying. We found however that young grain is far less sensitive, and wheat, oats and barley when sprayed when four or five inches high showed no effect even when the spray was used at one-half stronger than the above formula.

It was found in the experiments that certain plants, notably "Wild Mustard" and "Wild Buckwheat" were badly "burned" by the spray even when the grain was entirely unaffected thus there may be somewhat of a secondary value to the use of this spray.

The question in the minds of the farmers before applying this poison is whether it will kill or seriously affect his stock, should they get into the field so sprayed. No one expects to place his stock upon a steady diet of this poisoned grain for a long period but he wishes to be sure that should the stock get to the sprayed field for a time, they will not be injured. We feel no hesitation in saying that from the amount of poison shown upon the grain by actual analysis and from tests made by the State Entomologist, and quoted above, stock would be liable to no injury unless fed solely upon this poisoned material and even then, unless the feeding was continued for some days. It is of course evident that no such long continued feeding could occur unless purposely carried out as a test. It should always be remembered however in using this poison or any other poison that is strong enough to be of value, that reasonable care and intelligence is imperative in handling such materials.

Among other poisons which have been used with good effect against grasshoppers is the well known "Criddle Mixture" which is merely a mixture of Paris Green and horse manure—usually the proportion of one part of Paris Green to about one hundred parts by measure. The Paris Green is stirred into a quantity of water and then this aqueous mixture is stirred into the manure, adding enough more water to make the mixture of about the consistency of bran mash. This is an excellent means of killing grasshoppers but owing to the large amount of horse manure required to poison large areas, it is more feasible to use this in small tracts like garden patches. The mixture is simply scattered throughout the garden by means of a paddle. The mixture as normally used is not poisonous to poultry, although it might be harmful to young chicks.

Another device similar and no more efficient is a mixture of bran, Paris Green and water—usually about two parts of Paris Green to about twenty-five parts of bran. In some cases this mixture is sweetened by adding syrup or molasses. Care must be taken not to place this mixture where it will touch the plants.

Since we found the Arsenite of Sodium so satisfactory in our spray tests it was tried in a mixture somewhat similar to the Criddle described above and tests show the new mixture to be in some ways better than the former and certainly considerably less expensive. The best formula for this mixture so far as we have tested it is as follows: Sodium Arsenite one pound, horse manure one hundred and twenty to one hundred and fifty pounds, molasses (any cheap grade) one pint. Dissolve the arsenite in water and then add to the manure, stirring well. The mixture, which may perhaps be called the "Minnesota Mixture," may be used exactly as the "Criddle," but owing to the cheaper poison used and to the fact that so much poison is not required we have found it more economical. Its attractiveness as a bait is fully as noticeable as with "Criddle" and in fact we feel that the addition of molasses has improved the value as a bait. In order to test its effect on poultry we fed two roosters upon the mixture for some time with no bad effects. We tried also the effect of corn boiled in strong solutions of the Sodium Arsenite and by careful tests found that nearly one-half a gram of the poison was required

to kill a full grown rooster. Of course, this amount could not be obtained in a day's feeding upon the grain and foodstuff in the poisoned horse manure by any one chicken.

Aside from its value against grasshoppers another valuable point was noted in regard to this new mixture. Flies are attracted to this and we find that they are killed in great numbers by feeding upon the horse manure. In the experiments with the roosters above quoted, we found over a quart of dead flies on the floor of the shed after the mixture had been exposed for one day and careful tests and counts convinced us that the mixture actually attracts flies in considerably increased numbers. Following out the idea here presented we would suggest such measures as the spraying of piles of horse manure exposed at barns, etc., with a solution of eight ounces of Sodium Arsenite in about twenty gallons of water, to which has been added one half pint of molasses. This solution seems well adapted for spraying almost any exposed filth which may serve as a harboring place for flies. We hope to follow out several other experiments along this line if opportunity offers, since this poison appears to offer much promise and can be purchased at very much lower rates per pound than Paris Green or most of the better known insecticides.

During the summer (1911) numerous farmers had reported to us that they did not believe that the hopperdozers killed all of the grasshoppers; in fact, many of them believed that unless the grasshoppers actually fell into the trough and were thus drowned in kerosene they might revive. As soon as opportunuity offered we tried a long series of tests to show the actual effect of the kerosene under different conditions. As a result of these it was determined that the effect of the kerosene may vary somewhat when used very late in the season and with certain species. Trials made with hundreds of young grasshoppers of the harmful species showed that mere contact with the cloth wing, wet with kerosene, resulted in death within a very few minutes in every case. The same results held with crickets whether young or adult. With adults of a few of the species having notably long and ample wings, the results varied and while in some cases they were killed, some survived so long that it is possible that they might eventually recover. Our explanation lies in the fact that the ample wings, folded fan-like, serve to draw the kerosene from the surface of the body by capillarity. The action of the kerosene depends upon its reaching one or more of the spiracles and it is evident that this lessening of the amount of kerosene by the tube-like foldings of the wings must result in lessened effect.

The conditions thus observed simply add another reason why the hopperdozer, like sodium arsenite or any other control method, must be applied in early May and June to produce most effective results. There can be no doubt of the effect of these several methods when used early but when the man most affected will still delay, vainly hoping for the weather or Divine Providence to intervene, he should not attribute the failure of his trials to the methods but to his own delay.

Various grasshoppers lightly wet with kerosene on the under side of the body were affected as follows:

SPECIES.	HELPLESS.	DEAD.
M. femur-rubrum	5 seconds	1 minute
M. atlanis	15 "	2¼ "
M. bivittatus	20 "	2 "
M. bivittatus	10 "	1 "
M. femur-rubrum	30 "	2 "
M. bivittatus	45 "	10½ "

This latter specimen is inserted to show the slower effects in long winged forms. This was very noticeable in such species as Dissosteira carolina, Arphia pseudonietana, etc.

In connection with our spraying experiments it may be well to include here Mr. Howard's observation in 1912, showing features to

be avoided in this process and incidentally recording results of certain experiments of his in 1912:

"Although I was not supposed to give any attention to the economic phase of the subject of grasshopper destruction, for my own information and that I might be armed for the future, I took occasion to make a few investigations. During the previous year you had been testing a modification of the South African locust spray, adapting it to Minnesota conditions, and thought it to be very effective. As one of the originators and perfectors of that spray, I was anxious to see how it acted under local conditions. I took it upon myself to find a farmer who had grasshoppers quite badly and watch *his* spraying experiments with the sweetened arsenical spray. It will be as well in this brief report to summarize results and give the gist of my opinion upon spraying. The work carried out upon this farm was not very effective. *It demonstrated all the mistakes which could be made by a farmer in spraying.* In the first place, spraying was delayed until too late; hoppers were already molting to the adult stage. In the second place the grain was too high, already heading out, and there was plenty of tender pigeon grass below, of which the grasshoppers are very fond. In the third place, the spray machine used was not suitable; the fans of spray were not wide enough to meet and it did not throw the spray downward, so that relatively only a small portion of the grain was covered with spray. In the fourth place, the field was sprayed in strips, checker-board fashion, which leaves intermediate squares with no spray. My opinion is that locusts are not attracted to the sprayed grass by the sense of smell but when they come to a sprayed patch are induced to stay there and feed because of the sweetening in the spray. Therefore, unless we have a species rapidly migrating, as is the case with the S. African locusts, the whole field must be sprayed.

Spraying to be successful must therefore be done early before the hoppers have passed beyond the third stage, and if possible while they are in the first or second stage. As most of our destructive grasshoppers oviposit along roadways and in abandoned land, these areas can be sprayed and no harm done before the grain is more than six or eight inches high, while the hoppers are still small and while it can be well covered with the spray. A suitable pump should also be used, one which will give an even pressure, and with nozzles which will throw fans of spray which will meet and insure the grain being covered thoroughly. I would not advise the checker-board system of spraying for the reasons given above.

To test more thoroughly the question of whether grasshoppers and locusts are attracted by any odor in the spray, I made a few cage experiments with such odors as oil of rosemary, karo syrup, and fermented molasses and syrup. My tests of these gave negative results, as none seemed more attractive than untreated grass. I am strongly of the opinion, after very careful consideration of the subject, that locusts are not attracted by odors, but by taste, i. e., when they come upon something which suits their sense of taste, they remain there and feed until satisfied or some other stronger factor causes them to move away. In this connection, I also tried a test in the field with several sweetening substances in the spray. The following substances were used: molasses, karo syrup, fermented molasses, beet sugar molasses and locusticide. The sweetening substances, except of course the locusticide, were combined in the usual formula for the spray as recommended by this office.

The spray was applied at Foxhome on July 5th, on a weedy and grassy roadside, along a field of grain where grasshoppers were very thick. The plots were 15 feet square and on July 9th the plots were examined and dead grasshoppers were looked for as far as 30 feet into the grain field. The following number of dead hoppers were found:

Molasses	40 dead
Karo syrup	192 "
Fermented molasses	102 "
Beet sugar molasses	409 "
Locusticide	136 "

The beet sugar molasses seemed to furnish the greatest attraction, though the odor is not more attractive than that of the other substances. The grasshoppers present were M. bivittatus, M. atlanis with a few M. femur-brum. They were mostly in the fourth and fifth stages and a few were lting to the adult age.

The objection may be raised to this experiment that no barriers were ced about the plots and thus we were unable to ascertain exactly how many re killed. My endeavor was to have conditions as nearly natural as ssible; and the dead grasshoppers were traced for a sufficient distance into grain field. Of course, we did not ascertain how many escaped destruction, t that was not the point for which I was working in this test.

I was disappointed in the effectiveness of the Locusticide and attribute to the fact that there is a difference in the sweetening substance used in e American made product. The Atlas Preservative Co., of London, are w sending, free of charge, a couple of drums of the English made article, om the lot used in South Africa, and which was found so successful. This n be tested another season."

Mr. M. C. Tanquary of Illinois had charge of most of the field ork in spraying in 1911. He began his work June 5th at Fergus lls and conducted a series of tests to show the effect of Sodium rsenite both upon grasshoppers and upon the growing grain. ese tests were made in part at Foxhome (Wilkin Co.) and later Beltrami (Polk Co.) and again in part at Redwood Falls.

Protection of Gardens.

There is no question but that poultry, where it is possible to ke use of it, is a most valuable adjunct in keeping down the grass-pper pest around the house. Turkeys in particular have an in-iable appetite for these insects and are not only of great value in s connection, more so than in any other variety of poultry, but o as we all know, bring a very handsome price in the fall. This gument alone is one to induce all farmers to raise more poultry, rticularly turkeys.

Poison baits for grasshoppers can be used to advantage in a gar-n, a poison bran mash, (two parts Paris Green and twenty-five rts bran by measure) or the "Criddle Mixture" (Paris Green one rt, fresh horse manure one hundred parts, enough water to make e mixture soft) or some modification of it (see Minnesota Mix-re page 30). We have found by experimentation that the iddle Mixture can be safely used in places where full grown fowls ve access, though it might be dangerous where there were young ickens.

In using poison baits in the garden, care must be taken not to ce any compound containing Paris Green or arsenic in any form se to or in contact with a plant, since if rain occurs and the ison is washed down to the roots, the plant is likely to be serious-injured.

In the case of a small garden plot, practical protection could be obtained before the grasshoppers acquire wings, by placing twelve-inch boards on edge about the garden, thus making a complete fence twelve inches high and tacking on the upper edge a three or four inch strip, so that it will project two inches or more on the field side. On the outside of this twelve-inch board, just below the stripping, place a band of tar, and renew it in order to keep it sticky.

Mr. Blatchley in his report on the Orthoptera of Indiana, speaking of turkeys as a remedy for grasshoppers, states as follows: "Under the leadership of an experienced gobbler, almost their entire time during the summer and fall months is spent in wandering over the fields and pastures in search of the fat and juicy nymphs of locusts, grasshoppers and crickets. Indeed, most of the luscious white and brown meat of our Thanksgiving and Christmas dinner was once, grass, then grasshopper and finally turkey. No better and more practical remedy can be devised, for the damage which the insects do it, especially in these days of "turkey trusts" often more than compensated by the value of the pounds of flesh which this domesticated fowl stores up from its favorite food of locusts."

ENEMIES OF GRASSHOPPERS.

In spite of the fact that these insects appear to be the natural prey of many animals both large and small, the inroads made upon their ranks are so insignificant compared with the countless thousands left to attack our crops that we cannot rely upon these enemies as particularly helpful allies. Yet that they make some impression is evident and the species aiding man in this particular, even in a very slight degree should be mentioned here. Probably the help rendered is more extensive than would appear. We list the forms observed in this state preying upon grasshoppers.

Fig. 19. A Robber Fly, *Promachus vertebratus*. Original.

PLATE

E. L. WOOD, del.

SOME MINNESOTA GRASSHOPPERS

Predaceous.

INVERTEBRATES. Insect: Various robber flies, (Asilidæ) notably *Promachus vertebratus, Erax aestuans, Stichopogon trifasciata, Proctocanthus milbertii* and others.

Predaceous beetles as follows: *Pasimachus elongatus, Ptersostichus lucublandus, P. sayi, Calosoma calidum, C. frigidum,* feeding upon adults and eggs; *Carabus sylvestris* and *C. sylvanus, Cicindella vulgaris, C. purpureaus, C. auduboni* and *Amara sp.*

The Meloid, *Macrobasis unicolor.*

Amongst the beetles it is quite possible that *Elaterids* and *Staphylinids* feed upon the eggs.

Fig. 20. *Calosoma frigidum.* Kirby.

Hymenoptera: *Sphex ichneumonius, S. pennsylvanicus, Chlorion cyaneum, Pompilius americanus, P. atrox, Ammophila intercepta, Bembex fasciata, Lampronota sp.,* and various ants, the latter attacking only small nymphs.

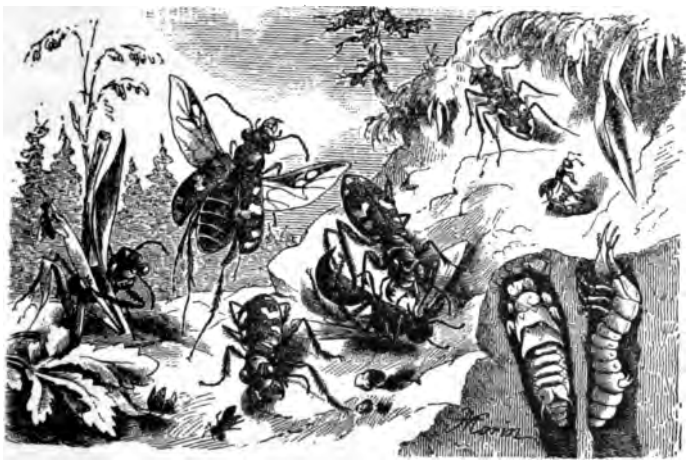


Fig. 21. Tiger Beetle, all stages. After Brehm.

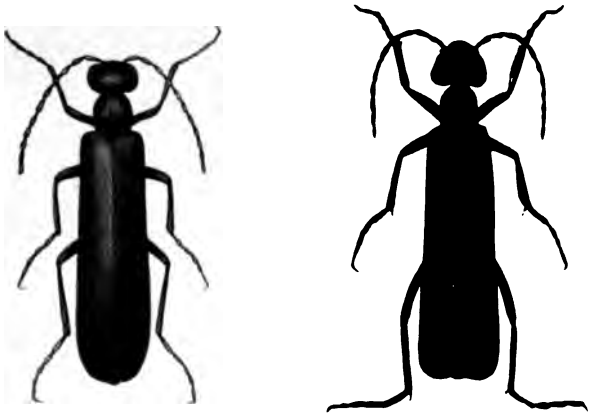
Orthoptera: The striped Ground Cricket, *Nemobius fasciatus,* feeds upon eggs.

Arachnida: *Trombidium sp.* Undoubtedly many small grasshoppers fall a prey to spiders also.

EXPLANATION OF PLATE II.

1. *Arphia (tenebrosa) pseudonietana:* 2. The Carolina Locust, *Dissosteira carolina;* 3. *Dissosteira carolina,* young stage; 4. *Dissosteira carolina,* showing color variation; 5. The Two-striped Locust, *Melanoplus bivittatus;* 6 and 7. *Melanoplus bivittatus,* immature forms; 8. The Red-legged Locust, *Melanoplus femur-rubrum.*

VERTEBRATES. Mammals: The thirteen-lined Gopher (*Spermophilus tridecemlineatus*) and probably other gophers. Skunks also known to have a fondness for grasshoppers.



Figs. 22 and 22½. Black and grey form of Blister Beetle, *M. unicolor*. Original.

Fig. 22a. Blister Beetle larva, second stage, in egg pocket of *M. bivittatus*. C. W. Howard.

BIRDS: A large variety of birds feed upon grasshoppers. Amongst these observed to thus feed here and reported by Mr. Somes are the Black Tern, Brown Thrush, Wren, Yellow Warbler,

Fig. 23. Thirteen-lined Gopher, *S. tridecemlineatus*, which catches and devours grasshoppers in the fall.

thern Shrike, Rose-breasted Grosbeak, White-crowned Sparrow, rris Sparrow, Bobolink, Cow-bird, Red-winged Blackbird, adow Lark, Crow Blackbird, Crow, Kingbird, many of the aller birds of prey, also Prairie Chicken, Quail, Cuckoo, Turtle ove and English Sparrow.

REPTILES: Reported by Somes. Garter Snake, Northern Swift, Northern Sand Lizard, Bell's Painted Tortoise.

AMPHIBIANS: Toads and Frogs.

FISH: Nearly all of our fish will take grasshoppers falling into the water or thrown in.

Parasitic.

INVERTEBRATES. Insects: *Muscina stabulans* (reported as distinctly parasitic in our work), *Helicobia helices* (possibly a savenger only), various species of Tachinids (Tachina and possibly other genera were found in August in the thoracic cavity of *Dissosteira carolina, M. bivittatus, M. atlanis, Melanoplus dawsoni, Spharagemon collare, Orphulella speciosa* and others.

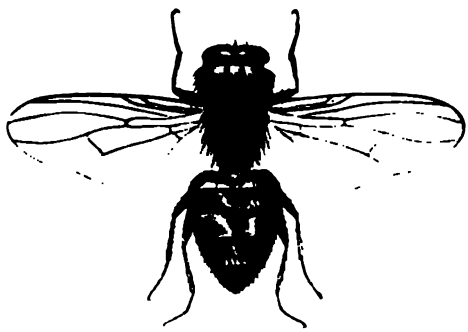


Fig. 24. The Non-biting Stable Fly, *Muscina stabulans*. Original.

A Bombylid: *Systaechus oreas*. Pupated but died before emergence of adult as reported by Howard. Several species of Phorids, parasitic, according to Howard, either in the grasshoppers themselves or upon the pupæ of fly larvæ found within the hoppers. From eggs obtained at Foxhome, a small hymenopterous parasite emerged late in the fall of 1912.

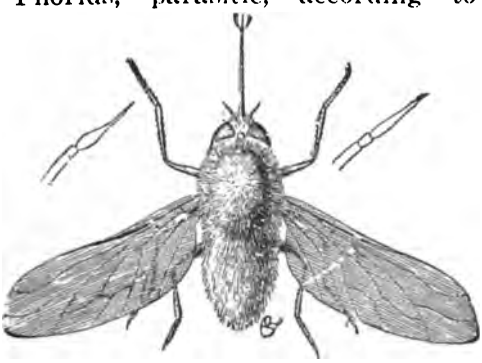


Fig. 25. A Bombylid Fly, *Systechus oreas*. After Riley.

Worms: Nematodes, "Hair-snakes" were found in the body cavities of *M. bivittatus* and *M. differentialis*.

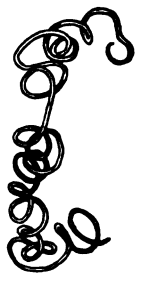


Fig. 26. A nematode parasite, (Gordius?) found in body cavity of grasshoppers.

PLANT PARASITES. According to Howard's observations a bacterial disease was the most destructive enemy of grasshoppers this season, attacking practically every species, especially *M. bivittatus, M. atlanis* and *M. femur-rubrum,* and the Oedipods, such as *Dissosteira* and *Spharagemon.* Quoting from Howard's report:

"Even nymphs in as early as the fourth stage were attacked, especially of the Melanoplods. The rainy season seemed to encourage the spread of this bacterial disease the past season and many valuable observations were made. It is to be hoped that another season the causative organism may be found where we can have suitable laboratory facilities and equipments for the work."

Fig. 27. A grasshopper nymph killed by bacterial disease, C.W.Howard

The fungus *Empusa grylli* was as usual quite common. The rains of the summer encouraged its growth and spread, but had we experienced warmer weather, coupled with dampness, it would have been more destructive.

Fig. 28. Carolina Locust, killed by fungus, *Empusa grylli*, C.W. Howard.

Some of the above enemies deserve more than a passing notice. *Macrobasis unicolor,* for instance, adults of which do much damage when they are known as "blister beetles," is interesting in that, in the larval stage it preys upon grasshoppers. It was quite destructive in Minnesota in 1911, its being present in large numbers being undoubtedly due to the presence of an abnormal number of grasshoppers. Quoting from Mr. Howard's field notes:

"Two varieties of this species are common in the western part of the state, one black, the more common, and one gray. The eggs are laid in the ground. The young larvæ upon hatching find a grasshopper egg pod and feast on its contents, leaving only remains of shells when they have transformed to adult beetles. There are two generations in a season. Early in June larvæ in the last stage and pupæ were found in egg capsules in the field. By the middle of June adults were out in full force and were injuring flax, potatoes, peas and radishes. Many were found on wild vetch and milkweed. Eggs were laid late in June and early in July. The second generation of beetles appeared by the middle of August and lasted until early in September, their eggs hatching by the middle or end of September. The gray form did not appear to any extent in the second generation. See Figs. 22 and 22½.

The life history of these beetles is being worked out carefully and will *be reported on after* another season. They assist some in reducing the numbers

of grasshoppers, but not materially. The method of egg laying makes it difficult for the tiny larva to find an egg pod and when it does, each larva destroys only one pod and not always the whole of that. Their destruction to crops offsets the good they do in destroying grasshopper eggs. Only one case of injury (by the beetle) to a crop, flax, was reported this year, (1912), but the injury was so early that the flax was able to recover and mature a good crop of seed."

TROMBIDIUM SP. This red mite is another interesting enemy of the grasshopper, but we have always believed that too much importance was placed upon its services by our farmers, for we have personally observed many female grasshoppers ovipositing in late summer, although loaded with these parasites. It is in spring, then, when in the bright scarlet mature form, that it does its best work, consuming many grasshopper eggs and thus reducing the numbers of the pest. We quote from both Mr. Somes' and Mr. Howard's observations in 1911 and 1912.

"Our studies of the parasites of grasshoppers naturally began with Trombidium, the 'red mite' or as it is more commonly called 'the red bug.' There can be no doubt that this mite has a very decided economic value in its work against the grasshopper, but contrary to general opinion this really effective part of its work is accomplished early in the spring rather than in midsummer when it is so commonly observed. In my preliminary examination of the field early in May I found this mite present wherever I found grasshopper eggs in abundance and very frequently observed it actually feeding on the eggs. It is evident that every egg thus attacked means one less grasshopper to hatch. As regards the actual beneficial effect of the mites later in the season we are inclined to think that these are over-estimated. It has been frequently observed that grasshoppers bearing from several to twenty or more of these parasites still feed and appear normal in all their functions. In some cases where there has been very evident damage to the wings and even to the dorsum of the basal abdominal segments the hoppers appeared undisturbed in vigor or in appetite. When the hopper moults it frees itself from the mites but more or less of these soon become again attached to it. From our observations it appears that the really beneficial stage of Trombidium is the adult in early spring rather than the more numerous and conspicuous young in summer.

In our early examinations of the eggs we found small coleopterous larvæ associated with the Trombidium in the vicinity of masses of eggs. Through error these were not reared but they were doubtless Meloids and in all probability belonged to the genus *Epicauta*." Somes 1911.

* * * * * * * * * * * *

"Trombidium was very abundant everywhere I collected. Early in the summer engorged females were found in egg pods of grasshoppers in the soil. They apparently feed on the eggs of any grasshopper without distinction. By May 27th eggs of Trombidium were found in the soil and a life history study was begun. This will not be complete until next summer, so the details, all of which should be verified by another season's observations, are not given here. The Trombidium, while it does some good in checking the grasshopper plague, is not what has been claimed for it in the past. They do destroy some eggs, but at the most two or three eggs only are required for the engorgement of an adult, and a lesser number for the immature forms, so that only a small percentage of eggs is destroyed. The larval forms apparently do very little harm to the nymphs and adult grasshoppers. I have seen nymphs with thirty to forty engorging larvæ of Trimbidium going on successfully with their transformations." Howard 1912.

In 1911, Mr. Stoner, a field assistant, selected several specimens of *Melanoplus bivittatus* bearing abnormally numerous mites (26 to nearly 50 individually) and kept these under observation for a period of two weeks. He reported that the hoppers appeared normal in function and could observe no apparent injury due to the mites. During the second week, however, he reported that the mites on one of the hoppers were "drying up" or shrivelling.

The Tern, so common about the prairie sloughs, aids the farmer materially as these dry up toward the end of summer, by catching countless grasshoppers. Mr. Somes was so impressed by this fact in 1911 that he writes as follows:

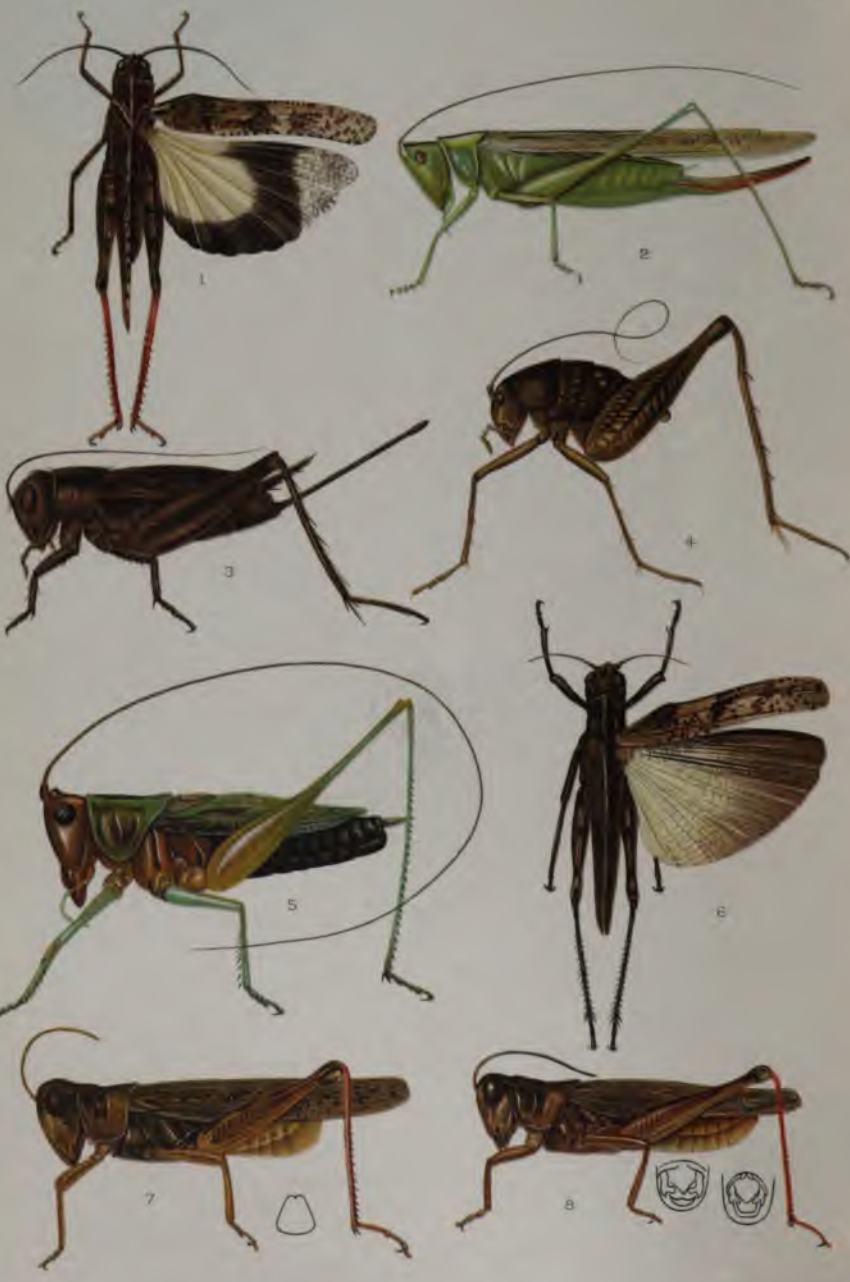
"The Black Tern is credited with destroying enormous numbers of hoppers; in fact, I have been told by two different farmers in widely separated parts of the state that this bird had virtually saved their crops by reducing the grasshoppers to normal numbers. In both cases the conditions were similar—the farms were located in a marshy area and as the marshes dried in summer the Terns turned to feeding on the grasshoppers and being present in large numbers they usually were very effective."

We also add here Mr. Somes' deduction from Mr. Zetek's notes on *Muscina stabulans* and *Helicobia helices*.

"At Fergus Falls two flies were reared from Melanopli. Of these *Muscina stabulans*, Fallen, is possibly a scavenger in habits rather than a true parasite. It has been known from a wide variety of hosts, ranging from the larvæ of *Aletia xylina* (The Cotton-worm) and bees to fungi and even rotting squash. In our studies however it was parasitic. The following taken from Mr. Zetek's notes gives the general data as to this species. 'July 17th. At the farm of Mr. Lomar, two miles west of Fergus Falls, I collected a number of *Melanoplus bivittatus* which contained dipterous larvæ in the thoracic region. They seem to be in the digestive tract. Placed in a tumbler cage. Several larvæ killed in hot water and preserved in alcohol. (Ac. No. 605.) Aug. 8, 10 A. M. Have examined the cage daily since the 17th ult. Adult flies observed this A. M. These have emerged since August 7th, 8 P. M. Pinned seven adults (Ac. No. 609) and placed in dry vial puparia of these as Ac. No. 610.' To go into more detail will say that the larvæ mentioned in this observation was found on numerous occasions in *Melanopuls bivittatus* in numbers varying from one to eight in the thoracic region as stated. The living larvæ were clustered close about the digestive canal in every case observed. Although this species belongs to the Muscidæ, as now limited, we think that it must be parasitic although possibly also a scavenger in habits.

Helicobia helices Towns. This Sarcophagid has previously been reared from *Lachnosterna, Pieris rapae, Leucania, Melanoplus differentialis* and other hosts. In the case of this fly our studies would tend to lead to the opinion that this is indeed a scavenger rather than a true parasite. (Zetek.) *Melanoplus bivittatus*, adult, collected June 30, by Mr. Stoner at Ada in a wire cage in a field of barley. It was placed in a cage for experiments with mites. July 11 it was found dead and infested with larvæ. July 12, transferred by Mr. Stoner from Ada to Fergus Falls. I placed it in a tumbler cage. There are seemingly two kinds of larvæ,—two specimens are large and are probably Syrphids. One of these shows indications of pupation. The other four larvæ are longer (about 4 mm.) and flattened dorso-ventrally. The jaws are well pronounced. None preserved as there are too few larvæ. Aug. 8, 10 A. M., Cage has been examined daily and this A. M. found 4 flies *in it.* Pinned as No. 612. Exopuparia placed in a dry vial as No. 614."

PLATE III



J. L. WOOD, del.

A. HOEN & CO. BALTIMORE

SOME MINNESOTA GRASSHOPPERS AND CRICKETS

While it is true that sometimes a decided check is placed upon the increase of an injurious insect by some of its natural enemies, these agencies must not be relied upon by the farmer. These checks almost invariably act too slowly to be of any great value, and the farmer who waits for them to act, before acting himself, may loose his crop in consequence. Mr. Somes in his report to this office voices our sentiments exactly. He says: "It is vastly wiser to accept all of these natural agencies for the good they will do and to augment the destruction by such methods as man may devise. The hesitation and delay on the part of the farmer is in considerable degree responsible for the continued increase of the pest. I am convinced that if but a small percentage of the farmers in the infested territory had, last spring, (1911), used such methods of control as were known, and had acted at the proper time the damage from grasshoppers could have been very materially reduced."

Fig. 29. Grasshoppers killed by fungous disease are frequently seen clinging to tops of grasses.

EXPLANATION OF PLATE III.

1. ***Sparagemon aequale;*** 2. The Slender Meadow Grasshopper, *Xiphidium fasciatum;* 3. **The Small Striped** Ground-cricket, *Nemobius fasciatus;* 4. A "Cricket-Like Grasshopper," ***Ceviophilus sp;*** 5. ***Xiphidium nigropleurum;*** 6. The Clouded Locust, *Encoptolophus sordidus*, **female;** 7. **The Lesser** Migratory Locust, *Melanoplus atlanis*, and sec. view of last segment of **male;** 8. ***Melanoplus collinus***, and dorsal view of male genital plates of *M. luridus* on left and ***M. collinus*** on right.

MISCELLANEOUS NOTES.

Effects of humidity and degrees of atmosphere and soil upon eggs and hoppers were tested (Howard 1912) to some extent in connection with the carrying out of some preliminary experiments to test the efficiacy of plowing as a means of destroying grasshopper eggs in the soil. These experiments will be continued this winter.

As a result of our experiments in 1911, we had printed in the fall of that year, a "grasshopper poster" of some size, stating the situation and giving the remedial measures we had found good, including detailed directions for spraying. About 6,000 of these were distributed amongst those who had complained of grasshoppers, and through our field workers and institute men, to all farmers in infested districts who were interested in the problem. They were also given out to farmers at the State Fair of 1911.

One feature of our work was the formation of "grasshopper clubs" amongst the farmers and interesting commercial clubs by circular letters to take action, upon the ground that the interests of the farmer and the business interests of any town are closely allied. One commercial club promised to co-operate with us somewhat along the following lines:

Plan for Co-Operative Work by Commercial Clubs Against Grasshoppers.

The Commercial Club will buy two or more sprayers and a supply of several hundred pounds of arsenite of sodium. Believing that roadsides are one of the great sources of young grasshoppers, especially in the southern parts of the state, the club plans to spray all of the roadsides in four townships centering at the city.

The Club will hire a man to supervise and direct this work and two or more men and teams to handle the sprayers.

The man in charge will act also as a solicitor among the farmers and it is planned to ask each farmer to contribute $5.00 per quarter section.

The work will be begun early and carried out as rapidly as possible.

When the roadsides have been covered, it is planned to spray *such of the* enclosed fields as appear seriously infested if desired.

This plan appears to offer a means of securing the greatest possible amount of work with the minimum of expense and labor and permits of the work being carried on at the time when it may be most effective.

Our field workers this year both agree in saying that the seasonal conditions in the early part of the summer of 1912 are what saved us from loss this year, but that grasshoppers are still present and numerous and that *as soon as one or two seasons favorable to them are experienced, we will again witness their destructive work.*

In conclusion: After our special work of two years and more upon the grasshopper problem in Minnesota, we feel justified in saying that the control of injury caused by these insects is in the farmers' hands; they can, if they will, by following directions intelligently, and by co-operation, reduce this evil at least 75 per cent. Using the words of one of our field men, "every intelligent farmer should become a leader in this work". It is to be hoped that more grasshopper clubs will be formed, for organized effort in this direction is bound to meet with success.

BLISTER BEETLES.

One or more species of these soft-bodied Beetles, family *Meloidae*, were extremely abundant and destructive in 1911. This was to be expected on account of the great abundance of grasshoppers in 1909, 1910 and 1911, since the eggs of grasshoppers form the food of one or more species of these insects when in the larval stage. The relation of these beetles to grasshoppers is discussed in this report in the article on "Grasshoppers."

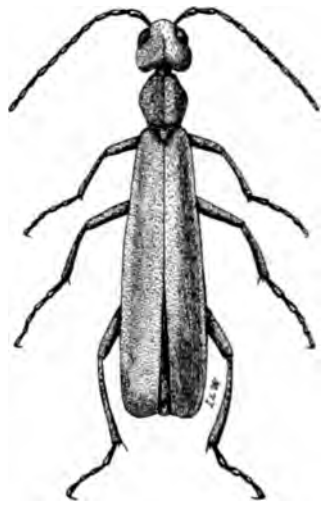


Fig. 30. A Blister Beetle. See also Fig. 22.

Unfortunately, the good done by them in the larval or young stage is more than offset by the injury done to various crops in the mature beetle stage. Specimens of these insects sent to this office in 1911 and collected in both 1911 and 1912 prove to be the black and gray form of *Macrobasis unicolor*. These beetles appeared in enormous numbers in different parts of the state almost simultaneously; i. e., about June 1st, and after that date letters of complaint gradually decreased until July 5th, or thereabout, after which there were, nevertheless, a few inquiries or requests for assistance with this insect until nearly the last of August. Alfalfa, clover, potatoes, various flowering plants, locust trees, etc., were sought by these insects, and we found them very difficult to poison in that they quickly left a crop so treated and went to another before the poison had had an opportunity to make any great impression on their numbers. We therefore advised sweetening an arsenate of lead spray, (three pounds of arsenate of lead in fifty gallons of water) where feasible to use spray. Where a spray could not be applied and the plants affected not too numerous, we suggested knocking them off the plants in the cool of the morning into a pan containing a little kerosene. Immediate action must be taken upon their very first appearance, otherwise they will

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THE WHEAT STEM MAGGOT.

From about July 6th to August 6th in 1912, an enormous number of letters were received expressing fear that the wheat crop was seriously injured by some insect, farmers basing their belief on the large number of "bald heads" noted in the grain fields. While in some few instances, individual fields showed serious loss, on the whole, the state probably lost on its grain crop only a very small fraction of one percent on account of "bald heads." Field workers reported these white heads to be most in evidence in the counties of Ottertail, Redwood, Swift, Yellow Medicine, Chippewa, Kandiyohi, Bigstone, Stevens, Traverse and Wilkins and complaints were received from Caledonia, Stephen, Kennedy, Deer River, Milaca, Northfield, Fargo, Windom, Perham, Osseo, Faribault, Litchfield, New Ulm and a score of other localities. This work was ascribed to the so-called "joint worm" by many, while a few called it the work of the Hessian Fly. As a matter of fact while the latter named insect caused a little loss possibly this year, and a few specimens of the pupal stage of a joint worm were received, these bald heads were due to the presence, in rather unusually large numbers, of the Wheat Stem Maggot, *Meromyza americana*, and each year witnesses more or less of its work, though as a rule it is not so much in evidence as it was in 1912. One need not confuse the work of these three insects. In the first place the Hessian Fly is never found *inside the steam*, the maggot being concealed beneath the sheathing leaf next the stem, and it is in this position that the puparium or "flax seed" is found. The joint worm larva on the other hand is found, in a gall-like growth, within the stem. The slender greenish wheat stem maggot is found also inside in stem, above the upper joint. The Hessian Fly maggot on the other hand works just above one of the lower joints, for the most part, and almost invariably causes the head to fall over and rest upon the ground.

Fig. 31. Wheat infested with Wheat Stem Maggot. Puparium also shown inside stem. Maggot and puparium on right enlarged, and imago above on left enlarged. Below on left, a parasite of the Wheat Stem Maggot, much enlarged. Lugger.

The Fly which produces the Wheat Stem Maggot is much smaller than the housefly, yellowish or greenish yellow in color. It lays its eggs on the plants in the spring and after hatching the maggots enter the stem. Feeding as they do above the upper joint, sap cannot enter the heads and the latter die before the grain matures. Late in July or early in August these maggots change, within the straw, to puparіæ, from which in time come the flies which mate and lay eggs on wheat. It is also said to attack several grasses. In the volunteer grains and wild plants the maggots spend the winter, turning into puparia in the spring, the flies emerging a little later.

Fig. 32. Gall-like distortions of Wheat Stem caused by presence of joint worm.

Nothing can be done, of course, when "bald heads" are seen in the grain, it is then too late for action. In stacked grain the insects which are away from the surface, toward or at the center of the stack, never escape, and these perish. Hence, as regards this insect, threshing from the stack is better practice than threshing from the shock. Early threshing, say the last of July or in the first week in August, doubtless kills many of the flies. After harvesting, all volunteer plants and will stuff growing over the field and particurally along fence rows, should be plowed under. Rotate, after wheat, barley and rye, with some crop other than these grains. Corn might well follow wheat. Field men report that the injury from these insects last summer was largely confined to "Velvet Chaff" while "Blue Stem" was almost free from injury.

CUTWORMS.

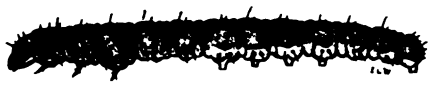

Fig. 33. Cutworm, injurious in 1911. Enlarged about twice.

With the exception of a few localities no report of serious Cutworm injury reached this office in 1912, but from about May 8th to June 1st in 1911, more complaints regarding cut worms arrived in the mail than ever before and letters of inquiry came in from time to time up to the middle of June, the culmination of injury appearing the last of May, at which time letters complaining of this pest represented nine-tenths of the entomologist's mail. Reports of cutworm damage came from almost every part of the state; we note in our files communications from Sauk Center, Minneapolis, Starbuck, Windom, Fosston, Northfield, Duluth, Glenwood, Zumbrota, Mankato, Austin, Rush City, Madelia, Hutchinson and Warroad, and a host of other places, showing wide distribution. It will be remembered that cutworms were bad in 1909, much worse in 1910 and the climax appears to have been reached in 1911. We believe this to be due to the unusual dryness of those years, retarding the growth of weeds, thus forcing the worms to prey more assiduously upon cultivated crops, and being particularly unfavorable to the growth and spread of fungous diseases which in ordinary seasons undoubtedly kill large numbers of caterpillars.

We have recommended various methods of combating them. Poisoned bait, made of bran mash, sweetened with cheap sugar, or syrup, or molasses, and made decidedly green with a liberal application of Paris green, is a very good remedy in a garden. A tablespoonfull of this should be put at frequent intervals among the plants subject to attack, not, however, nearer than eight inches to the plant, for in case of rain, the Paris green might be washed against the roots, and would injure or kill the plant. Thorough cultivation is an aid; pieces of shingle or board placed at intervals over the garden serve as traps under which the cut worms hide toward morning, and can be found and killed. Frequently, the depredator will be found within an inch or so of the plant cut, buried an inch under the soil. Young plants, like cabbage, cauliflower,

etc., when first set out in a small garden, should be protected by paper, or tin collars, or a barrier of some sort, which should extend into the ground an inch or so, and two or three inches above the surface. This can be removed when the plant becomes tough enough not to invite attacks from the cutworms. On large acreages fall plowing and thorough cultivation is perhaps the most practical treatment. Cutworms are always bad the next year after sod since they normally live in sod.

WHITE GRUBS.

Every year we have to treat upon these troublesome and destructive larvæ of the well known May beetle or "June Bug" of which we evidently have two species. In 1911 we received a few

Fig. 34. May Beetle or June Bug, (Lachnosterna) showing larva or White Grub, pupa and adult. Natural size. After Linville and Kelly.

complaints of this insect, but in 1912 it was much more troublesome; in localities, very destructive, injuring corn, hay, timothy and potatoes severely. In case of corn the roots are eaten and the corn is then blown over. Timothy in many places did not produce seed as a result of the work of white grubs upon the roots. Potatoes following sod were severely injured, five or six grubs being sometimes found in one hill, and, in places, clover suffered severely. The period of the most damage in 1912 was between the last of June and the latter part of September. In the last named month, a

field assistant, Mr. Harris, found these grubs being turned over in the stubble field by the plow, "literally by the thousands." In a field of clover, containing about thirty acres, near Granite Falls about twenty acres, two-thirds of the entire piece, had been killed by white grubs. On corn the injury was even more marked. In two fields at least one-half of the corn was down as the result of its depredations. Our field worker reported the views of nine farmers as follows:

1. The grubs were much more prevalent on land which is spring plowed than that which is fall plowed.

2. They were more plentiful where horse manure has been used as a fertilizer and especially where it has been spread by hand rather than with a spreader.

3. They are found only on the higher cultivated or semi-cultivated fields away from swamps, bottom land or marshes.

4. They have never been reported in any serious numbers before.

While observations from non-scientific parties are not always to be relied upon, it would appear since the above opinions appear to be quite unanimous, that they are of value. In discussing No. 1 it may be safely said that grubs turned up by the plow in the fall would be exposed to many more dangers before spring (their period of activity) than when plowed up in the spring, and the observation therefore seems to be an accurate one, and also an *argument for fall plowing.* The beetles seem to be attracted to manure and it is natural that eggs should be deposited more freely upon lands so fertilized (No. 2) and particularly if the manure were left in small or large piles and not spread evenly and becoming quickly dry. The roots of grass appear to be the natural food of the white grub (note No. 4 above) and when sod is removed it is perfectly natural that the grub should turn to the food substituted for sod over the same area. This accounts for the fact that corn or potatoes following sod in some districts are likely to be injured. This is also true of strawberry plants if set upon new land. Young spruce or seedling spruce are sometimes attacked, particularly if in land used for strawberries the previous year. It would appear that this pest is on the increase, possibly because more land is coming into cultivation.

To be effective any treatment against this pest must be begun as soon as the first signs of injury to the lawn are observed. To *wait until the* grass is brown and dead is like shutting the door

ter the horse is stolen. The most acceptable treatment at this ite appears to consist of copious watering of the lawn where pos- ible, accompanied by the use of some artificial fertilizer, like ni- rate of soda, (from 250 to 350 pounds to the acre), thus enabling he lawn by vigorous growth to keep ahead of the grub. One hould at least resort, in such emergency, to abundant watering where possible, even though fertilizer is not applied. The late J. B. Smith, State Entomologist of New Jersey, claimed to have obtained relief by the liberal use of ground tobacco stems scattered broad- cast and liberally over an affected lawn, followed by copious water- ing. He states that grubs disappeared after this treatment. This suggests, naturally, the frequent sprinkling of lawns with a tobacco decoction. Evidently, this would have to be quite strong and used generously. We have killed them by the use of bisulphide of carbon without injuring the grass, but the process is a slow one and im- practicable where large areas are involved.

After the lawn is dead in patches nothing remains for the owner to do but to re-sod or re-seed. Robins greatly aid in the ex- termination of the white grub, and may frequently be seen pulling them from under the dead grass. They should be encouraged in this good work. Moles and shrews eat them and we believe that skunks are also fond of them. If the grubs should be carefully re- moved and destroyed when brownish patches are *first* observed in the lawn their injurious work is at once stopped. They will be found just below the sod if they are responsible for its condition.

In addition to the above remedial measures, there is no question but that, in the case of injured field crops, hogs turned on to such ground as soon as the crop is harvested is one of the best methods of reducing their number, as they root out and devour them by the wholesale. Fall plowing and proper rotation are important prac- tices where these pests are active.

THE CLOVER SEED CHALCID.

Bruchophagus funebris.

Quite a large amount of clover seed is annually harvested in Minnesota, but the possible output even with the present acreage is materially lessened through the work of this tiny, four-winged fly, whose grub, commonly referred to as "weevil", destroys the contents of many seeds which, as the result of the presence of this parasite, become distorted, dull in color and are easily crushed by the fingers, the seed coat having become very brittle; in fact, this last acquired quality is one means of detecting the presence of the insect in new seed. It is to be noted in this connection that many of these distorted and poorly developed seeds, so infested, are left behind when a clover huller is used, and while the farmer notes a decided shortage in the yield of seed, he does not see the reason for it.

In at least one section of our state the raising of clover for seed has been abandoned on account of the work of this pest, referred to, as we said above, as "the weevil," and undoubtedly the state loses many thousands of dollars and the country at large many millions as the result of its ravages.

This chalcid is undoubtedly distributed over Minnesota wherever clover is raised whether for hay or seed. We have collected it in the vicinity of the following places, Ada, Bemidji, Chatfield, Duluth, Fergus Falls, Hinckley, Long Lake, Meadowlands, Montgomery, Owatonna, Shakopee, Stewartville, Verndale, Wadena, Windom, Wayzata and in the neighborhood of the Twin Cities. For four years, the study of this pest has been an "Adams Fund" project, that is, work done under a special fund and controlled by the Federal Government. As such it belongs more properly to Experiment Station work than it does to the work of the State Entomologist, and hence we treat of it here only in a general way, leaving the report on details and results to a station publication which we expect to appear later.

The insect is four-winged, small, compact, blackish in color, and a brownish tinge on the forelegs and all of the feet. The female inserts her ovipositor into a young seed, (at the time of egg laying very soft) and deposits therein a whitish egg. The grub, after hatching, eats the entire contents of the seed, sometimes, it is claimed, entering seeds other than the one in which the egg was originally laid. The transformations from larva to pupa occur *within a seed.*

Plants attacked are in no way injured for hay, but it is evident that the method of handling the hay crop has a direct bearing upon the infestation of the seed crop following. Red Clover, Mammoth and Medium, and some species of Alfalfa are attacked. We have not found it on Alsike or on White Clover, nor does it apparently work on Sweet Clover.

While the chief interest was centered in an effort to discover some method by which a larger yield of seed could be harvested in Minnesota, certain ecological questions, having more or less bearing it may be said upon the practical treatment of the pest, presented themselves for solution. Therefore, the details of the work were classified under two heads:

1. Economic; i. e., methods of control.

2. Biological or ecological; under which may be included the study of food habits, oviposition, incubation period, parasitism, number of progeny from single adult, number of generations in a year, period of most abundant emergence, and of the most abundant oviposition, period of life development, and its variation if any, length of larval life, of pupal stage, etc.

As stated above the details of work and results will later probably be made a subject for a station bulletin, and it would be out of place to insert them here at this time. Briefly, however, it may be stated that from our work of several years upon this pest, we conclude that a farmer desirous of raising seed, can secure a much larger crop by cutting the hay crop preceeding the seed crop, while the heads are still green or just coming into bloom, thereby preventing the maturing of the Chalcid and the consequent attack upon the heads of the seed crop appearing later in the same field. Manifestly, co-operative action amongst farmers of a neighborhood is necessary in this work. Otherwise a stand of clover which promises well for seed may be infested from an adjoining field where the above precautionary measures have not been taken. The experiments leading to these conclusions were conducted upon one, two, four and five acre plots on farms near Wadena, Audubon, Chatfield, Simpson and Verndale, but were supplemented by very many field observations and laboratory experiments. The above recommendation applies to Medium Red Clover only, not to Mammoth Red Clover. In addition to the above recommendations we might also advise the destruction or early cutting of all volunteer Red Clover along roadsides, fences, etc., and also the cleaning up and destroying of all clover waste about the huller. It is probable that where little or no earth covers seed, the insect may emerge in

BLISTER BEETLES.

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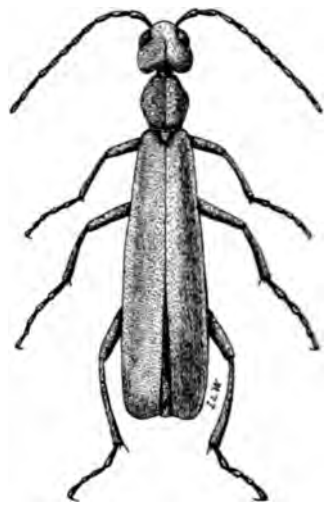

Fig. 30. A Blister Beetle. See also Fig. 22.

Unfortunately, the good done by them in the larval or young stage is more than offset by the injury done to various crops in the mature beetle stage. Specimens of these insects sent to this office in 1911 and collected in both 1911 and 1912 prove to be the black and gray form of *Macrobasis unicolor*. These beetles appeared in enormous numbers in different parts of the state almost simultaneously; i. e., about June 1st, and after that date letters of complaint gradually decreased until July 5th, or thereabout, after which there were, nevertheless, a few inquiries or requests for assistance with this insect until nearly the last of August. Alfalfa, clover, potatoes, various flowering plants, locust trees, etc., were sought by these insects, and we found them very difficult to poison in that they quickly left a crop so treated and went to another before the poison had had an opportunity to make any great impression on their numbers. We therefore advised sweetening an arsenate of lead spray, (three pounds of arsenate of lead in fifty gallons of water) where feasible to use spray. Where a spray could not be applied and the plants affected not too numerous, we suggested knocking them off the plants in the cool of the morning into a pan containing a little kerosene. Immediate action must *be taken upon* their very first appearance, otherwise they will

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THE WHEAT STEM MAGGOT.

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Fig. 38. Work of Birch Borer.

The Bronze Birch Borer.

The death of so many ornamental birches is almost entirely due to the work of the grubs of the Bronze Birch Borer (see Fig. 37). They make burrows somewhat similar to those made by the Two-lined Chestnut Borer. Sometimes the attack begins at the base of the tree but more often the upper branches are attacked first.

Fig. 37. Bronze Birch Borer. Ruggles.

The adult insect is a beetle about the size of the oak borer just discussed, but the body is bluish brown with no markings on the wing covers. The beetles are found flying during June and the first part of July. Eggs are laid at this time on the bark of the trees, one year being required to complete the life cycle. This insect attacks the different species of birch but seems to prefer the cut-leaf form. It also works on poplars and willows.

The Elm Borer.

The worst pest of the American elm in Minnesota is the yellowish-white footless grub of the elm borer. The presence of dead limbs and diseased areas of bark on the trunk of a tree are fairly sure signs that these borers are present. Often these signs are not noticed until the tree starts to leaf out in the spring, following infestation.

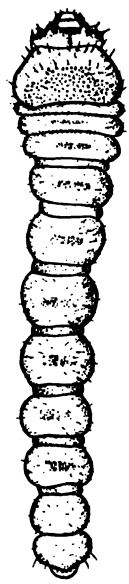

Fig. 39. Elm Borer larva. About twice enlarged. Original.

The adult Elm Borer is a grayish beetle about half an inch long. It has three narrow bands of red or orange markings across the wing covers. The beetles are found from June to August and probably eggs are laid on the bark of the elm trees at any time during that period. The eggs hatch into grubs which work beneath the surface. The first year, these grubs or larvæ work just beneath the bark and it is here that the most damage is done. The second year they work more deeply into the wood. If numerous in one region of the trunk, they cause the bark to shrink and shrivel at that place. The life history is not fully known. It is probable that it takes three years to complete the cycle.

3. It is difficult to detect an injury of this kind until too late to use a remedy.

4. A tree near a number of infested trees is quite sure to be infested although no outward sign of injury may be noted. Stripping off the bark is the only means of detection.

5. When once the grubs are at work in sufficient numbers, nothing can be done to save the tree.

6. As soon as detected that the tree is doomed, it should be cut down and burned together with the stump.

7. With some of the borers like the Two-lined Chestnut Borer, stripping the bark from the trunks and limbs would answer the purpose just as well as burning.

8. The felled trees instead of being burned may be cut into lengths and stored in closed basements where beetles cannot escape in the spring to lay eggs on other trees.

9. Valuable healthy trees in the vicinity of infested trees should, during the months when the beetles are flying, be protected by some repellant wash. This wash must have good sticking qualities and act in such a way that insects will not alight upon such a treated tree to lay eggs. As the important insects mentioned fly around during the last of May, June and the first part of July, it is at this period that the wash placed on these trees should retain its active qualities. These materials may be put on with a brush but it would be easier and simpler to apply them with a spray pump.

10. Some of the repellent washes that are recommended to be used are the following: Iron sulphide, ordinary whitewash, whitewash to which has been added one per cent of crude carbolic acid, and government whitewash. When one does not care to disfigure a tree in using the whitewash, lamp black may be added.

Iron sulphide is a fungicide and not an insecticide, but its sticking qualities, disagreeable odor and dark color make it valuable as a repellent wash.

11. As said in the beginning, co-operation among all concerned is essential. Individual work is practically useless. It is suggested that in the cities, park boards, and other boards or commissioners having charge of shade trees be given absolute authority to enter upon private property within the city limits and take the proper steps against infested trees.

Government Whitewash.

The whitewash used on forts and lighthouses may be made by slaking half a bushel of lime in warm water. Cover it to keep in the steam. Strain the liquid through a fine sieve or strainer. Add a peck of salt previously well dissolved in warm water, three pounds of ground rice boiled to a thin paste and stirred in boiling hot, half a pound of powdered Spanish whiting, and a pound of glue which has been previously dissolved over a slow fire. Dilute with five gallons of hot water. Stir well and cover for a few days. Strain carefully, and apply warm with a spray pump.

Formula For Iron Sulphide.

Lime, 10 pounds.
Sulphur, 10 pounds.
Water, 40 gallons.

Place ten pounds of unslaked lime of good quality in a barrel and nearly cover it with water. While the lime is slaking, add sulphur which has been run through a sieve to break up the lumps. Thoroughly stir it into the slaking lime, adding enough water to make a pasty mass. The barrel should now be covered, in order to retain the heat and the contents should be occasionally stirred. The time required varies with the quality of the lime. If it acts quickly, from five to ten minutes will be sufficient. If it acts slowly, fifteen minutes may be necessary. Now add a little water, stirring the mixture while it is being poured in. Add enough water to bring the total up to forty gallons. Then add three pounds of iron sulphate (copperas) disolved in about eight gallons of water.

* * * * * * * * * * *

Early in the fall of 1912 the writer sent the following communication to the press:

There is considerable alarm manifested at present over the condition of oak and maple trees, and to some extent birch and elm also. Some of this anxiety on the part of tree owners is well founded, but it must be borne in mind that toward the end of the summer, many of our trees are apt to look a little ragged,—a little the worse for wear as it were. Oak trees in particular, quite apart from the serious injury which may be inflicted by borers, are liable to a number of minor ills which though they may disfigure a tree and are sufficient to alarm the owner, are not liable to be of special importance. For instance, the oak pruner, larva of a beetle which cuts off the large twigs and smaller branches causing them to fall to the ground with leaves turned brown and withered, or which only partially broken off, hang in brown clusters among the living green, does no serious damage. In fact, the tree may be better off for a little pruning.

There are, too, several small leaf mining caterpillars which work between the upper and lower surface of oak leaves, frequently causing large propor-

tions of the foliage to turn brown and die. These causes for anxiety are for the most part unnecessary on the part of tree owners.

We believe that the very common and much to be deplored passing of some of our finest oaks and probably maple trees as well may be ascribed indirectly to the drouth of two summers ago and the unusual dryness of the early part of the summer of last year, a dryness which prevailed until late in the summer. Even after the copious rains of early autumn, as some of us will remember, a foot or two below the surface the earth was like dry sand. Manifestly, a tree not properly nourished is going to be less resistant to an attack of any kind than a tree well nourished, just as a human being with insufficient nutrition is going to succumb to disease, other things being equal, more readily than one in proper condition as regards nutrition.

Assuming that borers attack our trees every year, and they doubtless do, several on the oak and on the maple, one or more on the elm, the same on birch, the enfeebled trees succumbed, many of them last year, not a few this year, as the result of two years' attack, and partly because some of our borers require, we believe, two years to mature. Some of the trees, the condition of which are alarming the owners at present, were dead or dying last summer (1911) but their condition may not have been noticed at that time. During the year just passed such trees stood out in sharp contrast to the general dark green of the healthy growth about them.

It would seem too that the borers are not alone responsible for the death of so many of our oaks. One or more fungous diseases were found working on the roots of doomed trees last summer, and the present condition of our oaks may be due in part to a plant disease, something akin to the disease which is killing the Chestnut trees in the Eastern states.

It should lie within the province of city park boards to compel owners of real property to take care of trees which are a menace to the property of others and we believe that they should be appealed to in cases of this kind.

One can generally easily tell whether borers are at work or have worked on dead on drying trees. By removing a little of the bark the burrows of the worms and frequently the worms themselves can be plainly seen.

Our Cutleaf Birches are very apt to succumb to the attacks of the Bronze Birch Borer. This depredator, too, can be seen by removing a little of the bark from the affected portion of the tree.

It must be remembered also that leaky gas mains are frequently responsible. Many of our trees in the Twin Cities which have been dying owe their death to this insiduous cause. When this is found to be the case, the gas companies should be appealed to to repair the leak and replace the trees killed.

Where only a few branches of a tree are affected so that pruning is practicable without serious defacement, such branches should be cut off considerably below the injured portion and destroyed.

THE LARCH SAW FLY.

This, like the Clover-seed Chalcis, is now an Adams Fund project, and consequently is best discussed in detail, in an Experiment Station publication.

Mr. Ruggles, to whom this project was assigned, reported upon the work of 1909 and 1910 in the Thirteenth Report from this office, page 109. The work has been pushed as fast as possible during the past two years, and touching briefly on the results it may be said, (1) Only 1 per cent of the specimens reared from a large number of cocoons were males. (2) Young larvæ were observed the last of August, 1912, making it appear possible that there is a second generation, though no pupæ were seen. (3) In the Insectary larvæ fed impartially on American Larch (Tamarack), European Larch and Western Larch. (4) Many young larvæ in the Cloquet district were killed in the fall by some agency, possibly an early frost. (5) Large black ants (specimens not obtained by observer) were found to destroy larvæ. (6) Koochiching County, in northern part of state, bordering upon the Canadian line, appears to be the worst infested area.

THE CAMPAIGN AGAINST THE HOUSE FLY.

The campaign against the house fly in Minnesota, begun in 1909, has been actively pushed during 1911 and 1912. Some of the city dailies, notably the Minneapolis Tribune, have printed frequently "Swat the Fly" articles, pointing out the danger accompanying the toleration of flies about the house and containing common sense directions for lessening the evil.

In July, 1911, this office published an illustrated circular of information, entitled, "New Methods of Combating the House Fly." The chief purpose of this circular was to emphasize the fact that the female house fly, in its adult stage, lives from *eight to fourteen days* before it begins to lay eggs, and that if co-operative effort in a neighborhood was made to trap flies during that period, beginning early in the season, the tremendous increase of the pest resulting from continuous and unchecked breeding during the summer could be reduced to a minimum. In other words, the public were urged

) use approved fly traps, and one was figured and described which t that time was attracting much attention and proving very effi-ient. This was the Hodge Fly Trap, and it is Prof. Hodge's son vho is credited with a remark which was perhaps responsible for his new method of handling the fly problem. In other words, it ccurred to the young man that it would be much better instead of naking ourselves prisoners, as it were, with screens, to trap the fly,)r as the boy expressed it, "Why not put the flies in jail and let our-selves out."

Fig. 42. House Fly on lump of sugar. Brues.

In the spring of 1912, in co-operation with the State Board of Health, we prepared and printed 13,000 copies of a large illustrated poster showing the evils resulting from tolerating the house fly and how communities and individuals might successfully guard against disease from this source. These were distributed both by the Board of Health and from this office to schools, health offices, commercial clubs, hospitals, women's clubs and other organizations throughout the state, finding such appreciation that toward the end of summer the posters could be seen placarded in many public places in towns and cities all over Minnesota. Some communities started systematic campaigns against flies, resulting in more or less freedom from the pest, depending upon the thoroughness with which they were conducted. Results would undoubtedly be more satisfactory if laws were created tending to make the eradication of such insects compulsory.

In the summer of 1912 the director of the Minnesota Experiment Station felt the need of a fly trap which would capture flies in wholesale quantities without the necessity of the traps being frequently emptied. The Engineering Division of the Agricultural College was asked to construct such a trap on the principle of the Hodge Fly Trap, which in turn is an improved modification of the old fashioned traditional fly catcher of the cheap boarding house and the country grocery. The result was a trap twenty-four inches

long, as shown in our figures. Three of these traps were delivered to this Division, two rectangular, and one of the shape shown in illustrations, which by the way indicate very well the plan of construction. These traps have been given a thorough test with most satisfactory results, no difference being noted due to the difference in shape. The screen used is the ordinary wire mosquito screen, and that and the small amount of lumber required made each trap cost us forty-one cents for material. A skillful carpenter can make such a trap in about three hours or less. The upper oval part (c)

Fig. 43. Stable Flies, 10,211 caught over cow in one day. Hodge.

Fig. 44. An easily constructed fly trap. Hodge.

serves as a receptacle which the flies enter through the openings in the top of the middle portion (b) made of screen and shaped like the roof of a house. Under this is the base board (a), upon which rest two tin bait pans. All three parts are held together by the hooks at each end, as shown. Space between baseboard and middle portion (between a and b) about one-half inch, and between this and bait pans through which space flies enter pans, about one-fourth inch. Figure 3 shows a cross-section of the trap, the arrows indicating how the flies enter the bait pan and then ascend through the 10 or 12 openings above into the large receptacle. Thes contrivances were before we were aware of it, painted a dark green by the carpenter, but it appears to be no obstacle to their use*fulness.*

The bait is a very important factor in using this trap. *It should ısist of bread and milk and frequently renewed.* That is, it ıuld not be allowed to dry up and consequently lose its attractive-ıs. The flies in the upper part, or receptacle, should be killed by immersing that part of the trap in hot water or pouring boiling water over it, or in any other way devised by the user and not injurious to the trap itself. These dead flies may be emptied out of the trap, the bait renewed and the trap reset.

Fig. 45. House-fly on nipple of nursing bottle. Brues.

We append herewith the result of several different days' use of the trap illustrated. These results were reported to the Chief of this Division by Mr. Dan Nelson, an employee, who was placed in charge of the traps with directions to keep a careful record of the flies caught: Dairy barn, one day, 1,700 flies; two days, 2,000 flies; dining hall, rear of building, two days, 3,000 flies; same place, two days, 3,000 flies; same place, five days, 13,000 flies; dairy barn, two days, 1,800 flies; dining hall, rear of building, three days, 6,000 flies; ne place, three days, 5,000 flies; same place, one day, 4,200 flies; the back porch of a dwelling house not far from a stable contain-

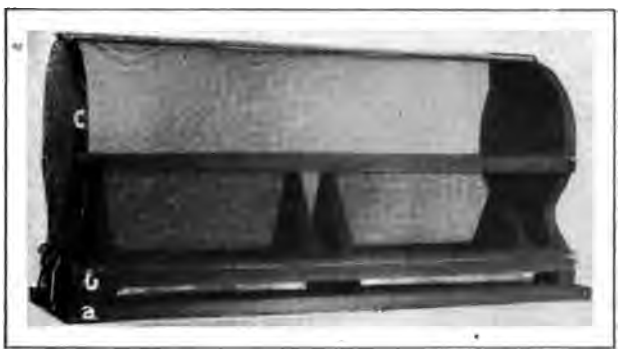

Fig. 46. The Minnesota Fly Trap.

ing a few horses, two days, 8,700 flies; same place, one day, 12,000 (twelve thousand) flies; same place, one and a half days, 18,800 (eighteen thousand eight hundred) flies.

While we wish to emphasize the importance of using bread and milk for bait, it should be noted that if anything more attractive is near by (tainted meat for example) drawing the flies away from the trap, manifestly the thing to do is to *place some of the more attractive material in the bait pans,* or add it to the bread and milk bait already in the trap.

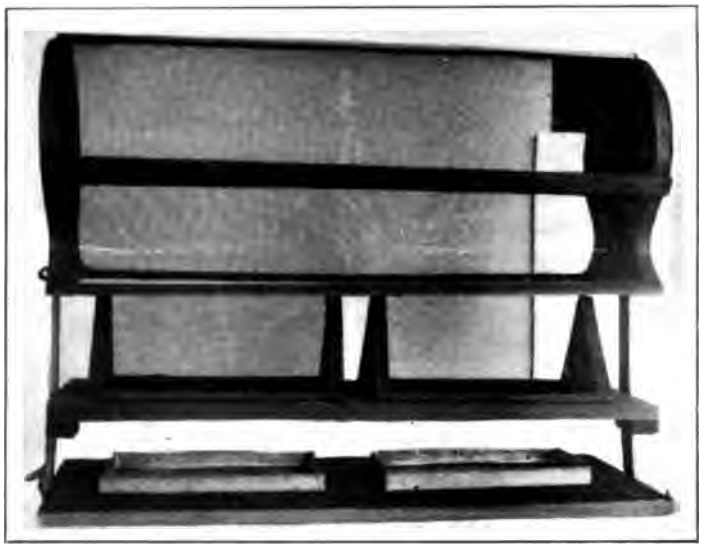

Fig. 47. The Minnesota Fly Trap, showing the three parts. The uprights at ends are not parts of the trap.

The recent statement of Prof. M. J. Rosenau and C. T. Brues, of Harvard, based on a series of experiments, that the biting stable fly, *Stomoxys calcitrans,* is largely responsible for the spread

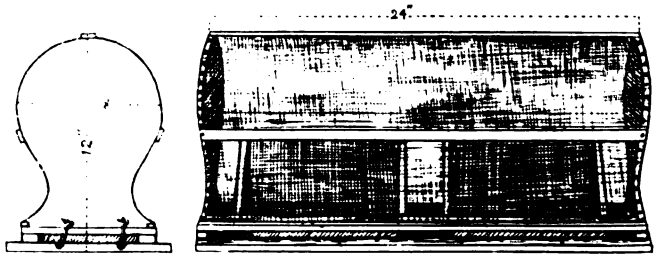

Fig. 48. Outlines of trap, showing structural details.

infantile paralysis, even though such claim may appear later to be somewhat premature, is another argument for trapping flies, destroying them before the eggs are deposited; since these eggs lay the foundation for an enormous increase of flies as the warm season progresses and a consequent increase in disease.

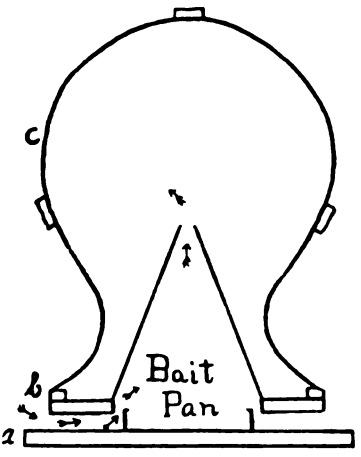

Fig. 48a. Sectional view of trap.

That the protection of garbage against flies and the quick disposal of same is most important in a campaign against the insect is shown by a report of J. H. Paine on some work along this line. Mr. Paine states (Psyche, Oct., 1912) that 22.4 per cent of immature stage of different flies found in garbage were those of house flies. In other words, garbage exposed for two weeks or longer is a menace to health.

ORCHARD SPRAYING IN 1911 AND 1912.

The results of this work are shown in detail by many tables, too voluminous to be included in a report of this nature. We append summary of results both for 1911 and 1912, as reported by Assistant Entomologist Ruggles, who had charge of these experiments. The co-operative orchard spraying both in 1911 and 1912 was for several reasons a failure in so far as any reliable results were obtained.

Summary of Apple Orchard Spraying in 1911.

"The flat orchard in the spraying experiment consists of eight rows of trees with fifty or sixty large bearing trees in each row. As said before, this orchard does not lend itself to a good spraying experiment, because the varieties are not placed in a satisfactory manner. The orchard was divided into five plots, each containing as nearly as possible the same variety of apples. One plot was left as a control or check. Three sprayings were given to each sprayed plot,—the first at the time the buds were bursting, the second just after the blossoms had fallen, and the third two weeks later.

On one plot three pounds of arsenate of lead was added to fifty gallons of 1-30 Commercial Lime Sulphur. Another plot was sprayed with three pounds of arsenate of lead added to the 4-5-50 Bordeaux mixture. Another plot was sprayed with two pounds of arsenate of lead in fifty gallons of iron sulphide. Another plot was sprayed with two pounds of arsenate of lead in fifty gallons of self-boiled lime sulphur.

In the control plot or check there was only 47.6 per cent of perfect fruit,—that is, saleable fruit. There were 17 per cent marked with curculio and 6 per cent injured by codling moth. The rest were diseased.

When two pounds of arsenate of lead were used the curculio injury was reduced from 17.1 per cent to 5.2 per cent in one case, and in another case to 5.6 per cent. When three pounds of arsenate of lead was used the curculio injury was reduced still more,—to 2.7 per cent in one case and 3 per cent in another. This shows that two pounds of arsenate of lead is an excellent insecticide against curculio, reducing the injury about 12 per cent, and three pounds of arsenate of lead will reduce the injury about 14 per cent. It is

robable that with four pounds of arsenate of lead to the spraying aterial the percentage of curculio injury would have been still maller, but it is doubtful whether it would pay to use the extra ound of arsenate of lead. It is a question also whether it is advisble to use three pounds instead of two pounds of arsenate of lead, here being really only 2 per cent of difference in favor of three pounds.

The tables also show, as mentioned in previous reports, that the codling moth is not the primary pest of apples in this part of the state. Even in the checked plots only 6 per cent were injured by codling moth. It will be noted, however, that spraying reduced this to 2 per cent.

About 13,000 apples were counted in compiling these tables.

Work of 1912.

In spraying the apples in the flat orchard in 1912, the orchard was divided into three plots. One plot was a control. Three rows were sprayed with iron sulphide, and three rows, 6, 7, and 8, were sprayed with Commercial Lime Sulhpur plus three pounds of arsenate of lead. The data of times of spraying are appended.

The summary of the tables show rather interesting results. We started out in the season intending to use commercial lime sulphur plus arsenate of lead, and iron sulphide plus the arsenate of lead. After the commercial lime sulphur plots were sprayed, the arsenate of lead ran out and rather than to wait for the material to come from the cities, we started to spray the plot rows 3, 4, and 5, with the iron sulphide alone. Throughout the season, these rows, 3, 4, and 5, were sprayed only with iron sulphide. On the control plots, we obtained only 40 per cent of perfect fruit; 25 per cent were marked with curculio, and nearly 7 per cent were marked with codling moth. The rest were diseased. In the plots sprayed with iron sulphide alone, and with the commercial lime sulphur plus the arsenate of lead, the results are surprisingly similar. For instance, the perfect fruit with the iron sulphide was 63 per cent; with the commercial lime sulphur and arsenate of lead, it was 64 per cent. With the iron sulphide alone, the curculio injury was reduced to a little over 8 per cent. With the commercial lime sulphur and arsenate of lead, the reduction was almost to 8 per cent. With the codling moth, with the iron sulphide alone, the reduction was about one-half that of the control, namely, 3½ per cent.

The results are so striking that we think the iron sulphide should be experimented with next season very carefully to find out whether it is as good an insecticide as these tables seem to show.

In all about 16,500 apples were counted, 3,500 more than in 1911.

Spraying Plums.

The plum orchard on the hill of the station grounds was again divided into three plots. This year the merits of iron sulphide and commercial lime sulphur with three pounds of arsenate of lead were tried.

On April 12, two-thirds of this orchard was sprayed with commercial lime sulphur, one part; water, nine parts, and applied as a dormant spray, one-third of the plum orchard being left unsprayed, as check. On May 20th, one-third of the same orchard was sprayed with the 1-30 commercial lime sulphur compound with three pounds of arsenate of lead to every fifty gallons of the mixture. One-third was sprayed with self-boiled lime sulphur solution, 10-10-50, to which was added iron sulphate at the rate of three pounds to every fifty gallons of mixture. On June 20th, these two last sprayings were repeated, the remaining one-third of the orchard being left as control.

Brown rot was particularly bad in 1912 and the results were very good in spite of the fact that apparently there should have been an extra spraying later in the season. In all 32,640 plums were counted.

Results.

In the control or check plot (unsprayed) 31 per cent of the plums were perfect. 23.5 per cent were marked with curculio and the rest were diseased. With lime sulphur and arsenate of lead, 45.4 per cent were perfect; 10 per cent were marked with curculio; rest diseased. With iron sulphide, 60 per cent were perfect; 11.8 per cent were marked by curculio; rest diseased.

This shows that iron sulphide is not the best insecticide for curculio, but is an excellent fungicide for brown rot, perhaps the best we have at this date. Present results indicate, however, that it is nearly as good for curculio as arsenate of lead with commercial lime sulphur.

CORN BILL BUG.

This insect, first reported to us in 1910, is proving to be a serious pest in Minnesota. On June 13, 1912, we received a report from Mr. E. J. Pond at Shakopee to the effect that about twenty acres of corn on his land had been ruined by the Corn Bill Bug, *Sphenophorus parvolus*. Mr. Babcock, in charge of our insectary, was sent to Shakopee, and his report of his findings and upon the summer's work with this pest follows:

Fig. 50. A Minnesota corn field (about 20 acres), practically destroyed by the Corn Bill Bug. Babcock.

"Upon looking through the breeding cage records, reference was found relative to the corn bill bug for 1910. The injury was caused at that time in the above named locality. The record as entered by Mr. Spooner is as follows: 'The field had been cultivated for forty years. Previous to 1910 almost the entire corn field had been covered by high water from time to time, thus furnishing an ideal condition for the existence of this pest. In the spring of 1910 the field was planted to corn and wheat, the wheat being more severely attacked.' In the spring of 1911 the field was plowed to wheat and corn, the wheat being all destroyed except about half an acre. On June 9th the corn showed evidence of attack in practically every hill.

On July 5, 1912, I made an investigation to determine the extent of the damage and its probabilities in the future. The field was planted to corn in the spring of 1912. Out of 25 acres of corn at least 20 acres were practically ruined. The beetles were so numerous that they could be seen traveling over the surface of the ground from place to place, but two days later only two

beetles were observed moving about, while some of the others were secluded in moist places, and still others feeding. The reason for this is probably due to the fact that on July 4th it rained, but during the four days following the sun dried the surface of the soil. It must also be noted that this pest thrives best in low bottom land where there is more or less moisture. There were hills of corn here and there that survived the attacks. The highest number of beetles observed attacking a single hill of corn composed of three stalks were thirteen. There were several ears of corn scattered over the field and more or less buried in the soil. In every case beetles were observed feeding upon the kernels of these ears of corn. The highest number of beetles observed feeding upon a single ear of corn were 43. However, the average number was about ten. Mr. Spooner stated that he observed evidence of the corn bill bug injury as late as June 9th.

The spring of 1912 was late and this fact I believe is the real cause why similar injuries were observed during the first part of July.

Fig. 51. Details of injury to corn plant, before and after unfolding of first leaves. Babcock.

The injury to the grain crop is not when it is well up, say 18 inches high or more, but it is all done when the corn or wheat is just coming up. The ground is barren and the over-wintered adults are hungry; hence, as soon as the young corn or wheat appears the beetles leave the native sedge and attack the more tender and attractive foliage.

Fig. 52. Dorsal view of *Sphenophorus parvulus*. Original.

The method of attack is thus; The tender shoot is discovered, the pest climbs upon it, turns itself upside down, that is, head down and body up parallel to the shoot. The claws grasp the shoot firmly; with its beak against the shoot the pest eats a round hole into and often through it, which is only one-eight inch or less in diameter. While eating the head is kept moving a little from side to side and backward and forward, sometimes a very little and sometimes a great deal, enough so that in place of a round hole it would sometimes be a long narrow and deep slit. In no case did I observe in green foliage a hole to be deeper than the full length of the beak, however in kernels of moist corn where several beetles were feeding, the entire contents of the kernel would often be eaten out. Where two or more punctures to a single shoot was made, the plant was sure to die. This is when the real damage is done. In most cases, the punctures were made from one inch above the soil to at least three-eights of an inch below the surface of the soil.

From observations made in the field and at the insectary the beetles were found to feed upon the tender shoots, but during bright, sunshiny days, the

hoots were attacked at the surface of the soil and below. On old plants, say 8 inches and up, beetles were found, in rare cases, feeding a few inches above he soil, and they were always found in greater numbers on the shady side ven on very young shoots.

On the 11th of July, copulating was quite general all over the field but I was unable to observe a single specimen deposit an egg either in the field or in he insectary.

A survey of the land adjoining the cornfield was made. On the east side was a creek and many trees, to the south was a meadow of wild sedge and red clover, on the west were weeds, shrubs, trees and the Minnesota river, to the north lay a small strip of land that was cultivated in 1911 but left untouched during 1912. Some wild sedge was growing here and there in the last named field. A few beetles were found feeding upon the sedge south and north of the field, but no larvæ could be found.

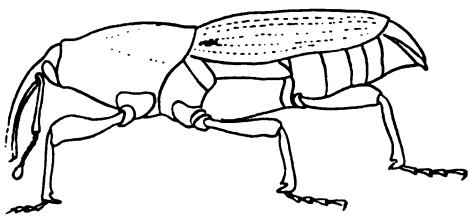

Fig. 53. Side view of *S. parvulus*. Original.

Over 150 adults were brought in to the insectary and kept in four large shell vials for seven days. No copulating was observed nor any eggs to be found but on July 18th, forty vials were used, four beetles in each vial. In about ten minutes two adults were observed in coition. The next day several pairs in coition were noticed. On July 20th, one vial contained three eggs and another one egg. These eggs are small elliptical and pearly, of about 1-16 inches in length. They were probably all infertile for I was unable to obtain any young.

In the insectary and in the out-door cage the corn bill bug was observed to feed upon corn, wheat, oats, barley, timothy, foxtail, and wild sedge, but I have never noticed it to feed upon any plant other than a grass or a sedge.

As late as October 15th, larvæ and *adult beetles* were found. The larvæ in every case were found on or partly in the inside of a bulbous root of the sedge, the open end of the cell being extended into the soil a short distance by silken threads mixed with soil particles. From this it is very probable that the corn bill bug passes the winter in two stages, one as larva in the bulbous root of the sedge and second as an adult in rubbish and other sheltered places.

Summary.

The corn bill bug is a snout beetle and varies from five-sixteenths to six-sixteenths of an inch in length, and is of a blackish color, with a few parallel lines, indented with pits, running lengthwise on the back. The beetles hibernate over winter in the adult stage, seeking shelter under grass, rubbish, in the soil and other suitable places. The larvæ also probably pass the winter in the bulbous root of the wild sedge, as they have been found as late as October 15th, the time this article was written.

In the spring the adults attack the wild sedges and grasses until the wheat, oats, timothy and corn start to come up, when they attack the tenderer and more palatable food supply. Egg laying takes place in late spring and early summer, the time varying according to the season. So far as known in Minnesota, there is only a single brood in a year.

Areas growing sedges or rushes, or any grass crop infested with the pest, plowed under in the spring and planted to corn, timothy, wheat, oats barley or rye is almost sure to be attacked. Since this insect attacks only grass crops, so far as is known, and the adults pass the winter under grass, weeds and in the soil, a preventive is suggested. Late summer or early fall plowing of grass land intended for corn the following year will probably destroy most of the beetles. It would be far better however to sow the field to some other crop than a grass or grain crop, instead of corn, as for instance, potatoes, tomatoes, beets, cucumbers, etc."

It is well to record here the occurrence last summer, 1912, of another "bill bug" larger and more robust than the one above described. It can evidently be referred to *Sphenophorus ochreus.*

Fig. 54. *S. ochreus*, dorsal view. Original.

We received specimens of this insect during the summer from a farmer who complained that they were "killing his chickens." These beetles have very sharp claws, and when seized by chickens they probably scratched and perhaps bit the fowls in the soft parts about the mouth, being quite able, on account of their size and strength, to draw blood and cause some distress to the fowls so afflicted. A little later, July 11th, one of our field men discovered this same beetle causing considerable damage to wheat at Redwood Falls on the farm of Mr. Winn. He reports as follows:

"I noted the following conditions: Damage may be done in either or both of two ways depending upon the stage of plant growth at which the insect first attacks the wheat. In the first case, where the insect attacks the wheat before it has 'headed out,' the weevil's attack is made by slitting the stem and feeding upon the inner portions of this stem; in such cases when the head appears it is white and without substance in the berries. When the attack is made later and after the head had opened the weevil simply feeds upon the berries of the wheat while still in the milk. Its position in feeding is characteristic,—it forces its way down among the 'beards', head downward, clinging to the beards or spines and eating through the "husk" feeds at leisure upon the soft grain. To escape capture or to change its feeding place it backs up the spines until free.

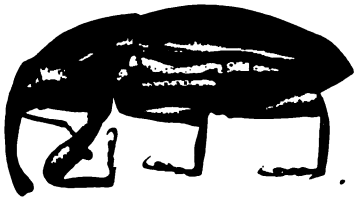

Fig. 55. *S. ochreus*, side view. Original.

All the damage which I have noted has been upon Velvet Chaff, a bearded wheat, while the Blue stem, a smooth or beardless variety was left notably untouched. Referring to map herewith attached, it will be noted that this first field examined, which was typical of others noted, is in large part a low tract of land, which in the meadow "A" is a rather marshy spot "a." The whole tract "B" is "Velvet Chaff" and throughout this we found the weevils present in large numbers—as many as three or four insects were found on single heads of wheat. The tract "C" which is exactly similar as to soils and drainage is of "Blue Stem" and yet here although there is no interval between the fields (not even a ditch or furrow) we found none of the weevils. But another fact enters here which may have some significance although this is as yet uncertain; the tract "D" is also of "Blue Stem" but here we found a very few of the weevils in the low ground at "d." Upon my inquiry I learned that "B" and "D" were both plowed in the Fall

while the tract "C" was plowed in the Spring. It appears possible that this spring plowing may have affected the pupæ at a critical period and thus accounted for the absence of the weevil.

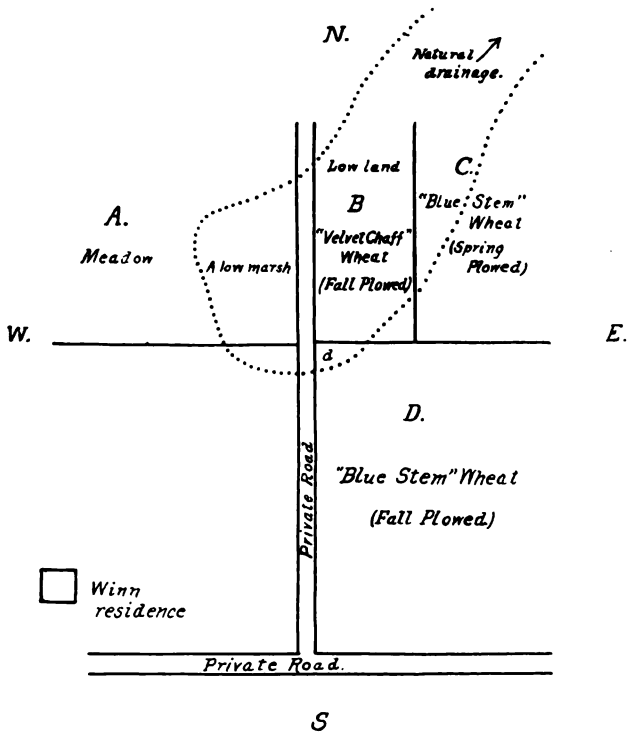

Fig. 56. Plan of wheat fields injured by *S. ochreus*. Somes.

This species of Sphenophorus, I have found rather sparingly in Iowa, and the southern parts of Minnesota during the past year, but never in large numbers such as were here presented. I may say that within a space one rod wide and three rods long, we picked over 100 of the weevils and some others escaped. I have always heretofore found the insect in low ground and associated with the "common rush" (Scirpus) of such marshy habitat. In the more southern states, it has been known to attack corn, but so far as I know, this is the first instance in which it has been known to attack wheat. The damage will doubtless be local and confined to fields in low ground such as the one here considered. Methods of control which suggest themselves are the planting of some less attractice crops on these low fields, such as flax, potatoes, beets or rape; drainage of the areas and possibly spring plowing and the thorough cultivation of the field."

A FEW HOUSEHOLD INSECTS.

This department has continued its practice of publishing circulars for free distribution from time to time, and among others three have been issued during the 1911 and 1912 biennium upon "Household Insects." These contained illustrated articles on Fleas, Bedbugs, Cockroaches, Carpet Beetles, Mosquitoes, Ants, "Silver Fish," Crickets, etc., and are in part reproduced herewith.

BEDBUGS.

Cimex lectularius Linn.

No housekeeper or landlord possessing any degree of pride is going to allow this disgusting pest to obtain a foothold upon his or her premises. Unfortunately its entrance into a house or hotel cannot always be foreseen or prevented; travelers coming in contact with people of careless habits, and occupying rooms, or berths in Pullman cars which may be infested are likely to carry this unwelcome pest either to another hotel or into one's own home, where the mere suggestion of "bugs" drives a housekeepr to desperation. To the credit of the sleeping car companies it may be said that sleeping cars appear to be surprisingly free from infestation, due probably to their process of cleaning.

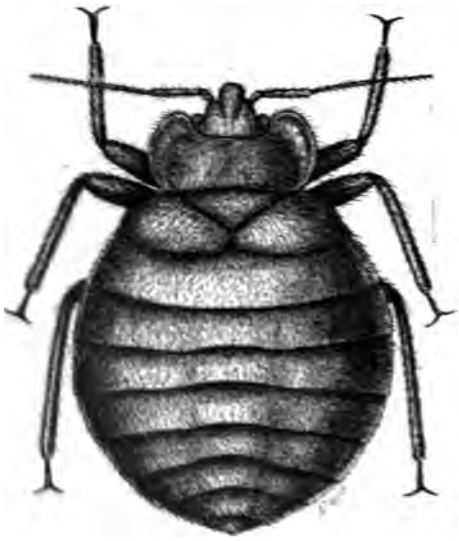

Fig. 57. Adult Bedbug, enlarged. Lugger.

Then, too, servants coming into a house or hotel from no one knows where (frequently from cheap lodging houses) sometimes bring the pest with them. They may be, as is the case with some people, absolutely indifferent to the presence or bite of this insect, and therefore, the bugs increase unmolested in the ser-

vant's quarters, until some day the housewife, not dreaming that the house is afflicted, is dismayed to note their presence in one or more rooms occupied by the family.

Life History.—The bedbug belongs to the order Hemiptera, the family Cimicidæ, and is a true bug. The accompanying illustration may give one an idea of the insect, which is pale yellow, more or less translucent, or brownish, or mahogany color if filled with food. It may show different degrees of red, depending upon the amount of blood it has absorbed. Like other true bugs, it feeds by inserting its beak-like proboscis through the skin, and as is very apparent, may well be the cause of infecting a human being with an infectious or contagious disease, the germs of which it may have obtained from a previous victim.

That bedbugs can go a long time without food is a well known fact (one is recorded as having been kept alive in a bottle for a year without nourishment) naturally losing color as the result of prolonged fasting, and even migrating, it is said, from one dwelling left unoccupied for some time and, in consequence, foodless, to another house, where the presence of human beings promises an abundance of nourishment. Fortunately for those of us who are obliged to travel considerably, these bugs are not active in winter. Associated with man, practically everywhere in the world, they have from time immemorial, apparently, regarded him as their special prey, not only to feast upon, but also to be avoided at times when he is awake, for they are strictly nocturnal in their habits, scurrying to their places of concealment in cracks or crevices of bedsteads, walls, mop boards, and the like, and under torn wall paper, at the coming of daylight. Depressed in shape, they are especially adapted to crawling into narrow cracks, and between two flat surfaces quite closely opposed.

Fig. 58. Eggs of Bedbug. Enlarged. Lugger.

The yellowish, white eggs, varying considerably in number (from six to fifty some writers state) are laid in cracks on bedsteads wainscoting, mop boards, under torn wall paper possibly, and wherever concealment is offered. These eggs hatch in about a week, and the cycle from and including the egg stage to the adult is said to be about seven weeks. Young and old have the offensive "buggy" odor,

shared by many others of this order, which odor is always indicative of their presence, even if one cannot see them. Personally the writer believes the odor of carbolic acid in a bed room to be quite as offensive as the bedbug smell, for the former odor advertises the fact that bugs are or have been present, and at once fills the guest with alarm, whereas in its absence he might remain peaceful in imagined security until he retired for the night.

It is believed that these bugs must at times get at least some nourishment from the moisture in newly felled logs, used while green in building log houses, but it must be borne in mind that there are bugs closely resembling bedbugs, and frequently believed to be the same, and yet not the real bedbug, found in cottonwood logs. So firm is this belief that the writer has had Westerners (Montana and Dakota residents) declare that they were absolutely sure of the identity of the bugs, and dared him to prove to the contrary. These insects, while quite close resembling the bedbug, belong to a different genus and species. Another species commonly taken for a genuine bedbug occurs sometimes in the nest of barn swallows, another on bats, or rather, where these animals "roost." According to Marlatt, species closely allied to the real bedbug, but not the same species, occur in England, one in pigeon lofts, another in martin nests, and the third in locations frequented by bats.

Remedies and Methods of Prevention.—The old proverb, "an ounce of prevention is worth a pound of cure," is applicable here. A housekeeper, either in a private house, or in a hotel, lodging house, or boarding house, should be extremely careful not to have any brought into the house, or at least, if suspecting their entrance, she should make heroic efforts immediately, before they become numerous, to eradicate them. Wooden bedsteds should be dispensed with in houses likely to be subject to bedbugs, and metal ones substituted.

Once well established in a house they are very hard to eliminate. This is particularly true, for obvious reasons, if a flat is infested. Fumigation with formaldehyde is hardly to be regarded as satisfactory. The same might be said of burning sulphur candles, though the latter, barring the unavoidable tendency to tarnish metal noted in the use of sulphur will, if used at sufficient strength, and for a long enough period, kill most or all of the bugs which are reached. Since some may not have come in contact with the sulphur fumes, and since the eggs may not have been destroyed by the first treatment, a second or third application would be necessary in bad cases

of infestation. The candle, or candles (for this remedy calls for a heavy dose of sulphur) should be placed in a metal dish, and this dish in a much larger vessel containing water, thus taking all precaution against a boiling over of the burning sulphur, and setting fire to the carpet. Close all apertures, including the keyhole, set fire to sulphur and shut the door, leaving the room closed for five or six hours. All metal such as nickel or brass, or silver (or gilt) will be tarnished if exposed to the fumes of sulphur, and should be removed from the room before the operation, or coated with vaseline.

Other more radical treatments are those of fumigation either with bisulphide of carbon or with hydrocyanic acid gas, the latter so dangerous to human life that it should only be used in extreme cases and under the direction of a practical entomologist, familiar with its dangerous properties. In fumigating with bisulphide of carbon about one pound of the liquid for every 1,000 cubic feet of space should be the proper proportions, placed in flat dishes, earthenware, crockery or wood. The operator should avoid breathing the fumes arising from this compound, and as this gas, when mixed with air, is highly explosive no light of any kind should be brought near the liquid, or into the room which is being treated until such room has been thoroughly aired. As bisulphide of carbon tarnishes, as it volatilizes, all metal, nickel, gilt, silver and the like should either be removed or covered with a coat of vaseline which will protect them. Close the room or rooms tightly for forty-eight hours, then open and ventilate. As the fumes coming from this compound are not only disagreeable, but also when breathed to any extent, cause sickness which might even, in extreme cases be fatal, the house should be vacated during treatment, and where one house of a duplex, or a "flat" is infested, there are serious objections to this method.

This division has found the following solution very effective: Corrosive Sublimate, 1 *oz., alcohol,* ½ *pint, turpentine,* ¼ *pint, thoroughly mixed. Spray this into cracks and crevices on bedsteads and elsewhere where the bugs may be secreted. Two or more applications at intervals of two weeks may be necessary.* If an atomizer cannot be obtained use a feather, or very fine brush. Label the compound *POISON,* and keep it out of the reach of children.

An old remedy is as follows: Spray joints and cracks with equal parts of kerosene and turpentine, then fill all cracks so treated with hard soap.

To make them leave a bed at least temporarily, the following is proposed. We have never seen this tried, and do not speak of it

from personal experience: Saturate cotton wads with oil of pennyroyal and place in various places about the matress.

This suggests the possibility of protecting one's self when obliged to sleep in a bed suspected of being "buggy," modyifying the method by putting a little oil of pennyroyal on one's body. The writer has secured immunity from fleas during the night by anointing his body with spirits of camphor. This might be effective with bedbugs also.

COCKROACHES OR "CROTON BUGS."

Ectobia (Phylloderma) germanica.

This pest is distributed practically over the entire globe. While it is not as obnoxious as the previous two insects in that it does not, like those, attack man personally, yet its presence in or about food is sufficient to elicit expressions of disgust from any but the most callous. The species under discussion is only one of several but it is the only one to be considered here in that it is the species which is most annoying to housekeepers of this section.

It is brownish in color, with two darker stripes on thorax, the adults furnished with thin wing covers under which are a pair of true wings. In the younger stages it is wingless. The adults are rapid runners, and both old and young are lovers of darkness, and quickly hide in cracks and crevices at the approach of light. The opening of a drawer or a cupboard in the daytime often send them scurrying away to more secure retreats. The female, which like the adult male, is a little over half an inch long, may frequently be seen dragging about behind her the oblong egg case, quite as long as she is. This case is packed full of eggs, and in a short time the eggs hatch, each egg case or capsule giving rise to a large number of young roaches.

It is claimed that this particular cockroach requires from four and a half to six months to reach maturity. It feeds upon all kinds of starchy food, is frequently a great pest in bakeries, and at times startles the patron of some restaurant by scuttling across the table under his very eyes. It is, therefore, one of the most obnoxious and disgusting of pests, even though it does man no direct harm.

Remedies and Methods of Prevention.—The cockroach has evidently, like the bedbug, learned discretion in its attitude toward man, and is extremely wary and on its guard against all poison baits. Once thoroughly established in a dwelling it is extremely dif-

ficult to eradicate. Particularly is this the case when it has taken possession of a flat or hotel, where, by running along the water pipes, it can avoid danger, traveling from room to room or from house to house.

This Division has tried various traps, and practically all the proprietary remedies, besides certain poison baits of our own invention, only to find that almost any remedy is useless as soon as this insect realizes, as it appears to, that it (the remedy) is aimed toward its extermination. We find, however, that they are frequently caught in small numbers in the Hodge Fly Traps.

Perhaps the most important advice to offer in connection with this insect is that the housekeeper should *at the very first appearance of the pest, begin a war of extermination immediately.* Every day of delay means a probable increase in the ranks of the enemy, and, as stated above, when once well established, it is a Herculean task to eradicate them. A careful and painstaking housekeeper, therefore, who aims at cleanliness in pantry and kitchen, has the advantage over one of more easy-going habits.

Powdered borax in some form appears to be the chief agent to be used against them, and probably forms the base of the well advertised and rather high priced roach powders.

A private house badly infested, where the housekeeper followed the advice of this Division, was completely freed of the pest by a faithful and continuous use of powdered borax. This was scattered along the mop-board in the kitchen, about cracks and crevices wherever they occurred, in kitchen drawers, about the water piper, kitchen sink, etc., every evening after the day's work was finished, and continued for about a week.

We, and others, have found that a compound known as "Hooper's Fatal Food," carried by druggists, is probably the best remedy for the cockroach evil, if its use is persisted in. It comes in flat cans, and should be dusted liberally and frequently in places where these insects occur.

ANTS IN HOUSE AND GARDEN.

The few species of ants found in this state constitute a very small fraction of the ant fauna of the world, represented as it is by probably nearly or quite 4,000 species, 2,000 or more of which are already known.

All or our common ants swarm at the mating season, at which time the males and females are winged, losing these temporary ap-

ndages later. The true fertilized females, or "queens" are the
;g producers in a colony and it should be noted in seeking meas-
res of relief, that unless these queens are killed, the colony goes on
ncreasing in numbers, no matter how successful one may be in kill-
ıng of the workers or imperfect females. The grubs hatched from
the eggs are helpless and cared for by the workers, but the small
white bodies one sees being carried about by the workers when a
large ant hill is broken into, or a colony uncovered, are not, as a rule,
either the eggs, or their grub, but cocoons spun by the grubs, and en-
closing the pupæ. These are the precious burdens which the ants,
terrified by the catastrophe to their dwelling, first seek to carry to a
place of safety.

Ants are very persistent in their food-seeking instinct, as many
a housekeeper has had occasion to observe, and yet frequently the
casual observer in a garden misjudges these insects, thinking they
are injuring a plant or a tree when they are really doing nothing
of the kind. For instance, the ants seen on peony buds rarely if ever
bite into the bud itself, but are attracted to it only on account of the
covering of "varnish" over the bud, which is to their liking. Again,
one frequently sees ants ascending snowball bushes, fruit trees, and
various garden shrubs. These ants are not injuring the shrubs or
trees frequented, but a little search on the part of the observer will
disclose numerous colonies of plant lice on the tree or shrub in ques-
tion, busily engaged in sucking sap through the bark or leaf. These
plant lice give up to the ants a sweet liquid, elaborate within their
bodies, referred to sometimes as "honey dew" of which the latter in-
sects are very fond. In fact, so fond are they of this exudation tha
they take every means in their power to protect these creature
which may be justly regarded as the ants' "cows." At least o
form of plant lice is so well appreciated by one of our small spec
of ants that the latter take the eggs of the former into their burro
at the approach of cold weather, and bring them up again in
spring. Indirectly, then, by conserving injurious insects, the
do injure our trees, shrubs and plants. For that matter the w
has seen a large snowball practically girdled and finally kille
large black ants. Further, our lawns and fields are sometime
figured by large mounds made by one or more species, and ev
small red ant may be a serious nuisance, though in a lesser
than the first named, when its nests get exceedingly nume
grass or in the flower bed.

Fig. 59. The Small House Ant, *Monomorium pharaonis*. Enlarged. Original.

It is in the household, however, that ants cause the greatest annoyance, mostly confined to the larger species which, *though nesting outside, sometimes find their way into the house*, and to the very minute red ant, *Monomorium pharaonis*, which usually does not nest outside, but starts its colonies in some warm location within the house. Ants are frequently found in bee hives, seeking such locations partly, we believe, for the warmth, and partly attracted by the honey. Ordinarily, however, in such situations they do little or no harm, for a good colony of bees can easily protect themselves and annihilate the ants if they become too numerous.

Remedial Measures.—The housekeeper's fight against ants within doors can be classified under two heads, first, protecting food material from their attack, and second (and far more satisfactory), destroying the colony or colonies, including the queen or queens, and thereby putting an end to their depredations. Under the first head we list, (a) the old remedy of scattering powdered borax about the shelves; (b) the placing of the legs of the refrigerator, or of the table or cupboards holding food in pans filled with water covered with kerosene; (c) placing a sponge or sponges full of sweetened water upon shelves frequented by ants, and when they are covered with these insects, dropping them into boiling water, and repeating the process; (d) poisoning syrup and molasses with an abundance of Paris green or arsenic, and placing it in shallow dishes in places frequented by the ants; (e) *a saturated solution of alum applied over shelves with a brush and allowed to dry, appears to leave a deposit which is obnoxious to the ants, and they avoid it;* (f) another poison said to be effective consists of 1 part powdered lead arsenate (probably ½ part of arsenic, or less, would be equally effective) mixed with five or six parts of honey; (g) oil of pennyroyal on wads of cotton, said to be effective in driving away; (h) removal of the special food which appears particularly attractive. One would have to exercise care in using the above poison baits, for if children or others ignorant of their nature should have access to them very serious results might follow.

However, all of the above, while remedial in their nature, fail frequently, to bring permanent relief, in that they do not reach the queen in the ant nest, and the numbers of the ants continue to in-

crease until she is destroyed. Therefore, it is of the greatest importance to seek for the nest, out of doors in the case of most of the species entering dwellings, but usually indoors in the case of the very small ant, almost microscopic in size, known as *Monomorium pharaonis* which, if it once gets a foot-hold in a house, is very hard to eradicate. In case of infestation by this species, find the nesting place, which, by the way, may be in a warm spot in the cellar, perhaps between the stones of the foundation walls, perhaps back of baseboards or other protective matter. When *absolutely sure* that the nest is found, try first squirting with oil can or syringe such liquids as kerosene, or bisulphide of carbon (gas explosive in presence of artifical light of any kind other than electric bulb) in an effort to wet the queen with kerosene, or kill her with the fumes of the second named compound. Bisulphide of carbon, by the way, has a most disagreeable odor, is very volatile, and the gas, if long inhaled, may cause sickness or result even more seriously if an individual is exposed to the fumes for any length of time. Gasoline might be used in place of kerosene, bearing in mind its dangerous nature. In case of failure with the above agents one must resort to either freezing (if conditions favor this process) or fumigation with hydrocyanic acid gas. Our experience in ridding a private house in Minneapolis of this pest, where it had been established and a great nuisance for eight years, may be helpful.

We first traced the ants to their nest in the walls of the furnace cellar, and tried injecting kerosene, gasoline, bisulphide of carbon into the crevices between the stones where the ants entered. This did not meet with perfect success, so in the middle of winter, with the family out of the house, we fumigated with the deadly gas known as hydrocyanic acid gas, and afterwards by opening all the windows, secured a temperature in the house something like 4 degrees below zero for three or four days, and the ants have not appeared since, although four years have gone by since the treatment. This, as will be seen, is heroic treatment, but sometimes the exigencies of the case demand it.

Sometimes some of the sticky "tanglefoot" mixtures, which can be brought in bulk quite cheaply are useful when applied to the outer side of foundation wall, in keeping out various kinds of pests which, normally outside, sometimes overrun a house. A three inch band of sticky tanglefoot of the right consistency applied with a brush would form an effectual barrier. As long as this is kept sticky no ant or other insect can cross it.

Ants in Lawn or Garden.— The large mounds out of doors, each of which is occupied by hundreds of ants, can be easily treated with bisulphide of carbon. Make eight or ten holes with a cane or croquet stake, about eight inches deep, in each mound. Into each hole pour a good tablespoonful of bisulphide of carbon, closing each hole with earth, and then throw a couple of wet burlap sacks over the hill, leaving them over night. One might have to do this twice possibly; or, in other words, until the queen or queens are killed. Where no mounds are present and there are only a few small hills, say three or four or five or six holes, a different method is advisable. We find that by pouring gasoline into the holes of such small colonies we can stop their work, using from half a teacupful to one teacupful when from three to six holes are involved. We frequently have to make applications at intervals of a few days, and sometimes even three are necessary. Do not be afraid to use plenty of gasoline, in order to reach the queen or queens which lay the eggs. This liquid, however, will kill grass or plants where it comes in direct contact with them.

The small and very common red ant which makes tiny hills on our walks, lawns and in flower beds is sometimes a nuisance. It can be destroyed by pouring a little gasoline into each hole; this, however, is a big job where they are numerous and is hardly worth while unless they are extremely troublesome. When ants are girdling a snowball or other shrubbery, we first have recourse to strong tobacco water to see whether we can drive them away. If they still persist in eating the bark, we advise uncovering the crown and larger roots, mixing up arsenate of lead with a little water, and applying it as thick whitewash to these parts. Arsenate of lead is a poison, which, however, applied in that way, would not injure the bush. Wood ashes placed around base of bush will sometimes drive them away.

THE SILVER FISH.

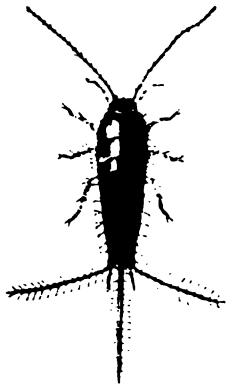

Fig. 59½. A "Silver Fish."

The illustration accompanying this article gives a good idea of the appearance of this insect, which, at times, is a pest in households. About half an inch long, silvery-white in color, almost fish-like in shape, quick in its movements. It is sometimes seen rapidly scurrying about among unused books on shelves not often disturbed, and in bureau drawers where clothing is stored. It belongs to the lowest order or group of insects, which ordinarily furnishes us with but few, if any, insect pests. Sometimes, however, the silver fish not only injures books, but also has been known to injure rugs made of silk, and evn destroy silk dresses by eating holes in the same. It also eats holes in wall paper in seeking the starch or glue beneath it. These injuries are brought about apparently by its appetite for the glue and starch used either as sizing in cloth or paper, or in the binding of books.

Remedies.—Careful housecleaning in severe cases should help in eradicating or lessening the number of this pest. Dusting shelves and drawers generously with Pyrethum (Persian Insect Powder, Buhach, Dalmation Insect Powder) would be beneficial. The insect should be killed whenever individuals are met with, and it should be borne in mind that frequent handling of starched and silk clothes will tend to render the goods so handled less likely to be attacked. Since they are fond of starch, the poisoning of starch with an abundance of arsenic, smearing the same on pieces of cardboard, and placing these poisoned baits on shelves and drawers where the insects are known to occur, presents an effective means of reducing their numbers. A similar poisoned bait prepared with glue in place of starch might be equally effective, though we cannot speak as frankly of this medium as we can of the starch. Inasmuch as this insect sometimes eats the sizing off of heavily glazed paper, leaving, however, the inked parts (text) untouched, indicating *a marked dislike for printer's ink*, we recommend when silk material, or anything in fact containing starch or glue, has to be stored away for any length of time, that the same be wrapped in several layers of newspaper.

CRICKETS.

One or more of our common field crickets may be at times a nuisance and a destructive pest when domiciled in a dwelling. However pleasant the chirp of "The Cricket on the Hearth" (and the writer confesses to being very fond of their music), when their song indicates the presence in the house of an insect which eats holes in clothing and is otherwise obnoxious, the particular housekeeper desires to take measures to remedy the evil. These insects are practically omnivorous, partial to almost any food product, are cannibalistic, and as stated above, will occasionally riddle an article of clothing. Marlatt in an article on the House Cricket (Bul. 4, Series, U. S. D. A. Bureau of Entomology) emphasizes the fondness of crickets for water and accounts for their wanton cutting and gnawing of clothing by their fondness for moisture, the intimation being that damp clothing is more likely to be injured than dry. He goes on to say, however, that any of the common field grasshoppers or crickets entering the house are apt to gnaw curtains, wearing apparel, etc.

We have been appealed to for help in ridding a house of crickets which, on account of their abundance, had become a nuisance. At our suggestion the afflicted parties used "Hooper's Fatal Food," dusting it about in places frequented by these insects, and report success. Note also what was said in the article on Ants, with reference to the use of tanglefoot mixture on the outside of foundations to prevent insects crawling into houses. Mr. Marlatt (op. cit.) claims crickets can be destroyed in large numbers by taking advantage of their fondness for liquids, and setting in places where they occur vessels filled with beer or other liquid. Many will doubtless drown in such receptacles. Uncooked vegetables, small pieces of carrots, or potatoes, thoorughly poisoned with arsenic may be used, taking proper precautions to prevent accident.

Crickets may be prevented from eating binding twine in the field by soaking it before use in a solution of bluestone.

MICE AND RABBITS.

Last winter field mice were exceptionally severe in Minnesota and complaints came to us in the spring, from many sources, of trees destroyed. One party lost a large number of fine young naples, a loss representing several thousand dollars; others lost fruit trees through their being girdled, still others shrubbery, etc. A girdled tree may leaf out and even blossom in the spring, but it is sure to die in the fall.

To all of these complaints this office has answered practically as follows: We have advised against early mulching (mulching if done

at all should not be done until cold weather after the mice have sought winter quarters) and we regard cover crops, such as oats, buckwheat, clover, etc., as conducive to mice injury. For that matter all weed growth and trash of any kind beneath the trees are [illegible]. It is unsafe to leave an orchard in sod. [illegible] in a tree at or just below the surface of the ground and any [illegible] or barrier [illegible]

[illegible] from that of rats. The latter will gnaw the tree and the marks of their large incisor teeth are plain to see. The finer marks of the [illegible] of the mice can be seen in the mud from which the [illegible] near or b

An application of a thick white wash (made by slaking quick lime in water) rendered a deep blue by the addition of a blue-stone (blue vitrol) solution appears to be a good repellant for both mice and rabbits. We have personally used this, and have known of nurserymen making use of it with success. It should be applied late in the fall and it would do no harm to make a second application during the winter if possible. This could be applied with a brush or with a spray and nozzle used for whitewash. The latter method would be preferable in treating shrubbery, and perhaps also rows of nursery trees, insuring more rapid and probably more thorough work. The now well-known commercial lime sulphur

Fig. 61. The Common Cotton-tail.

spray, (one part stock solution, 10 parts water) used as a dormant spray is also very useful as a preventive of attacks of rodents, both rabbits and mice.

Mechanical guards of various kinds are absolutely reliable and we figure several from an excellent bulletin issued by the Ohio Station. These may be of paper (the writer has used successfully several thicknesses of newspaper) securely tied on and extending a few inches below the surface. Rabbits have been known, however, to tear off paper wrappings under extreme conditions. We would advise against the use of tarred paper in this connection and of course all such coverings, except perhaps wire screen, should be removed in the summer. More durable are the guards of wood veneer, and

better yet, wire screen with small enough mesh to keep out the mice. This latter should be about 24 inches wide, thus covering the trunk for nearly two feet. Such protection can be used for several seasons. Of course, all guards should extend below the surface a short distance, (two or three inches). Wood and paper guards should always be removed in summer as they harbor insect pests.

A farmer should provide for "tramping" down about his fruit trees occasionally during the winter, tramping the snow down hard. If one can mound young fruit trees with earth, coal ashes, or leached wood ashes, or, best of all, cinders in the late fall so much

Fig. 62. Baby Rabbits. Ohio Experiment Station.

the better, first clearing all rubbish away from the trunk and making sure there are no mice runaways or burrows in the soil next to the tree. These mounds need to be only about twelve inches in diameter and about five or six inches in height. Mounding should be done late in the fall, and these mounds may be permanent, possibly requiring some renewal each year. They may also be used in connection with the wire screen employed against rabbits.

Cornstalks two feet in length, fastened closely about the trunk of a fruit tree with hay wire, make an effective barrier against rabbits. Ballou (Ohio Bulletin No. 208) recommends that they be cut into two foot lengths when brought from the field before being fed

to the stock. After the stock have stripped the blades off, the stalks of uniform length can be gatherd up and tied in blades for future use. Care should be taken to remove the wire when the stalks are taken away, otherwise, if left on, a tree may be eventually girdled and die.

POISONING: Finally, we can resort to poisons in our warfare against mice, and probably the best agent is sulphate of strychnine (be sure to purchase the sulphate). This may be used in two ways; (a) upon crushed wheat, or (b) upon alfalfa hay or green alalfa,

Fig. 63. Four little rabbits. How cute! Protected through sentiment. Ohio Exp. Station.

the employment of the last named being of course limited to summer. The Department of Agriculture recommends *crushed wheat* for this purpose in preference to whole wheat, (Farmers' Bulletin No. 352) and the process of preparing this poison bait is as follows: Dissolve 1 oz. of strychnina sulphate in 2 gals. of water by boiling in a closed vessel; pour this over 60 lbs. of crushed wheat, stirring it through the mass thoroughly until all the wheat is thoroughly wet. This should be used at once, and care should be taken to scatter the grain where birds or other animals we desire to pro-

tect cannot reach it. Perhaps wide boards with inch crosspiec nailed under them to keep the boards raised from the ground, as re commended in an Ohio bulletin is the best contrivance, or employi pieces of drain tile and placing the poison inside with a long har led spoon (op. cit.) We would also suggest placing this bait, p

Fig. 64. "They promise to be good." Ohio Experiment Station.

tected from birds of course, at the base of trees we wish to sav along nursery rows. This bait can be used at any season and yo mice are said to eat it greedily in summer. In using it over an tended area, where it would not be practical to use board or one is naturally obliged to take advantage of all the natural co offered, in order to protect birds, etc.

During the winter the best vehicle for carrying the poison it is claimed in the government bulletin referred to, is Alfalfa hay. It was advantageously used in a mouse plague in Nevada up to the time green food appeared in the spring. The formula recommended is as follows: Good green alfalfa hay chopped into two inch lenghts, 30 lbs.; sulphate of strychnia, 1 oz.; and water five or six gallons or as much as the hay will absorb. Dissolve the strychnine as recommended above. Place 30 lbs. of chopped hay in a large metal receptacle and first sprinkle it with three gallons of fresh water, thoroughly mixing it. Then sprinkle the poison over this dampened hay and thoroughly mix it. The hay can then be sacked and is ready for immediate use. It cannot well be kept for several days but should be used while fresh. This can be distributed by hand, near mice burrows ar along surface trails. In cold weather drop into the underground burrow. Stock should be keut out of fields for several days after treatment until rain and weathering makes this bait harmless.

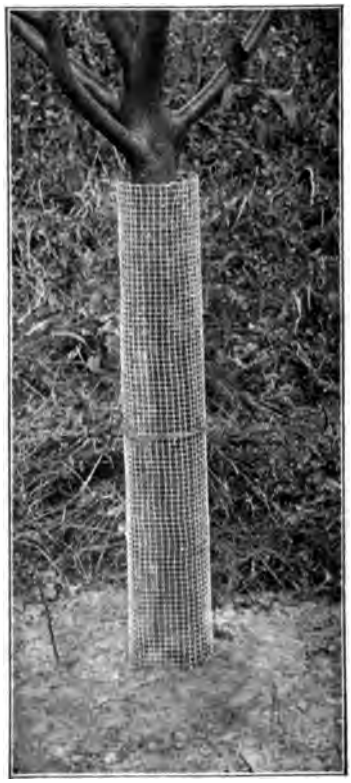

Fig. 65. Apple tree, protected by wire screen. Ohio Exp. Station.

While green alfalfa, prepared in practically the same way as the hay, was used with considerable success in the Nevada mouse plague by Government workers, even in the spring when green food was abundant, it calls for greater care in distribution, quickly withers, and does not particularly commend itself to the writer as being equal to the other two baits described.

Strychnine, of course, is a deadly poison, and the greatest care should be observed to prevent accidents both with the sulphate itself, with the solution and with the utensils used, and with the bait itself. The sulphate costs wholesale, in the neighborhood of 75 cents per oz., and being more soluble in water than any other form of strychnine should always be used. Farmers interested in com-

bating mice on a large scale should see the Government bulletin above referred to.

Inasmuch as mice are devoured by skunks, foxes, weasels, owls, and hawks, it would seem desirable to protect all or most of such animals which are commonly regarded as "vermin" and destroyed.

Rabbits.

A more foolish law than the one created by recent legislative enactment making it illegal to hunt rabbits in Minnesota with ferrets can hardly be conceived since they are amongst the worst pests of horticulturists, nurserymen and farmers, and yearly cause losses in the one state of Minnesota amounting to many thousands of dollars. The more rapid and complete their extermination in this State, the greater the satisfaction in owning nursery stock, fruit trees and ornamentals. While they show preference to certain cultivated trees and shrubs, when snow is on the ground they are apt to turn to anything which offers in a most unexpected way. They appear to be particularly fond of *Spirea Van Houtei* and last winter we noted Japanese Barberries which had been cut down to snow line. Even the spines on Rugosa Roses appeared to offer no obstacle. As a rule injury is done after the arrival of snow, yet this fall, 1912, we found them attacking young apple trees early in October while abundance of green food was still at hand. An ounce of prevention is certainly worth several pounds of cure in

Fig. 66. Guard made of wood veneer. Ohio Experiment Station.

connection with these animals. They begin to produce young in the spring, in Minnesota perhaps as early as April, and continue during the summer. Hence destruction of adults in early spring will mean, if co-operation amongst neighbors is practiced, a marked lessening of their numbers to work havoc the following winter. We find them very susceptible to poison in the spring before they can get green food and have destroyed them by powdering crystals of sulphate of stychnia, in the small bottle in which it is sold (use the head of a heavy nail) and putting in slits in small pieces of apple, a very little of the powder, as much as can be held on the point of a penknife. These poisoned baits should be distributed in such a way that other animals or children cannot get at them, and in general it may be said that one cannot be too careful with poisons of any sort. The use of poisoned baits need not necessarily be confined to early spring, but they are probably more effective then. Evidently rabbits get wary of certain bait, seeing individuals of their kind perish after partaking of it. It is well, therefore, to substitute parsnip or carrot for the apple, when the latter ceases to be effective. The bodies of poisoned rabbits should be carefully buried.

Fig. 67. Corn stalks used to protect trunks. Ohio Experiment Station.

Another method of poisoning, applicable in winter or spring, which has the advantage of not endangering the lives of birds and other valuable animals, is the poisoning of new twigs or suckers, freshly cut from appletrees, by dipping them in a sweetened strychnine solution and placing them about the orchard or nursery in the neighborhood of trees needing protection, or in rabbit runways. See that these twigs bear buds and that the buds are poisoned. When using poisoned fruit, unpoisoned fruit should be kept

out of their reach. If poisoned pieces of apple or carrot are used in winter, it is a good plan to place the baits on the end of little sticks so that they are conspicuously above the snow.

A gun, or gun and dog are useful agents to use against rabbits. They also readily fall victims to the old-fashioned "figure four" trap, and in the woods to snares, as every boy knows. Among raptorial birds, found in Minnesota, which prey upon rabbits are

Fig. 68. A tree "bridge-grafted." Ohio Experiment Station.

Marsh Hawks, Coopers Hawks, Red-tailed and Red-shouldered Hawks, the Long-eared and Short-eared Owl, the Barred Owl and the Great Horned Owl; the indiscriminate slaughter of these must have a more or less direct effect upon the number of rabbits. The fact, too, that in some states, the open season for rabbits is very short, and that on many farms and large estates, no hunting is allowed, help their increase.

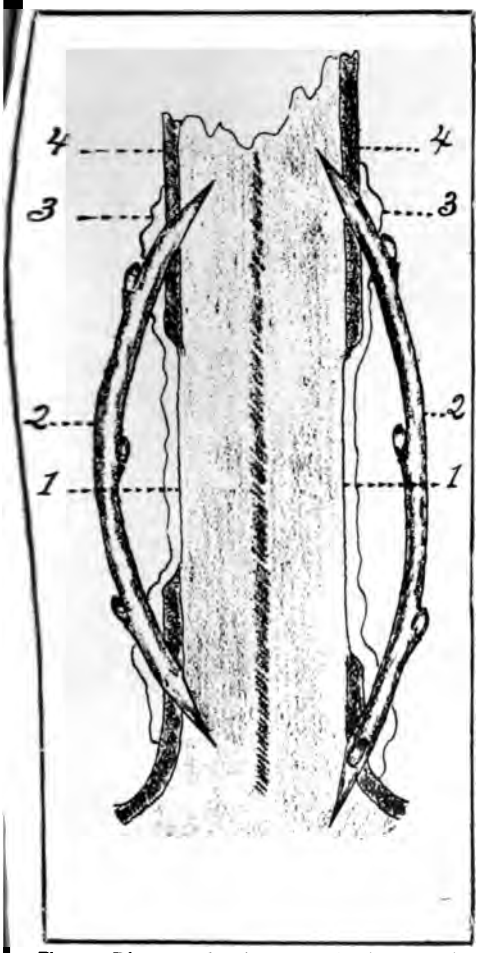

Fig. 69. Diagram, showing plan of bridge-grafting. Ohio Experiment Station.

ally worth several pounds of cure.

Applying repellent washes to tree trunks and shrubbery (see above) is strongly recommended by this office, as is also the mechanical guards described on a previous page.

We have not much faith in the low so-called "rabbit-proof" fence, since in times of drifted snow it is no obstacle, and unless a barbed wire is buried below the fence or the lower edge of the fence itself inserted a few inches in the ground, the animals may burrow beneath it.

A valuable tree girdled by rabbits (or mice) can sometimes be saved by bridge-grafting, which consists of inserting the end of several scions into incisions in the live bark below and above the injury, the ends of each scion being first cut into a wedge-like shape. Grafting wax should be carefully and liberally aplied at points of union of scion with stock, and all wounds thus carefully covered, This requires some technical skill, and, as said above, "an ounce of prevention" is gener-

INSPECTION OF MINNESOTA NURSERIES AND OF IMPORTED STOCK: RECENT FEDERAL LEGISLATION AFFECTING NURSERYMEN.

In 1911 fifty-two nurseries were inspected and the $232.75 collected therefor was deposited with the State Treasurer. Nurseries receiving certificates in 1911 are as follows:

Vine Grove Nursery
Rose Hill Nursery
Thos. Redpath Nursery
Deephaven Nursery
Hawkinson Nursery
Hoyt Nursery Co.
Park Nurseries
Howard Lake Nurseries
Strand Nursery
Wright Co. Nursery
Jewel Nursery Co.
Sacred Heart Nursery
Madison Nursery
Orton Park Nursery
St. John Nursery Co.
Amber Lake Nursery
Wedge Nursery
Turtle Lake Nursery
Fairmont Nursery
Tolleson Nursery
National Nursery Co.
Friedhoff Nursery Co.
Albert Lea Nursery Co.
Hutchinson Nursery
Johnson Nursery Co.
Minnesota State Nursery Co.
The Faribault Nursery
Dodge County Nursery
Pioneer Nursery
Vinegar Hill Nursery
Clinton Falls Nursery
Farmers Seed & Nursery Co.
Winnebago Nursery
Mankato Nursery
Mitchell Nursery Co.
Fillmore Co. Nursery
Preston Nursery
Andrews Nursery
West Concord Nursery
Byron Nursery
Plainview Berry Farm
Wilwerding's Nursery
Northwestern Nursery Co.
Sivert's Nursery
Mayfield Nurseries
Deerfield Nursery
Spring Valley Nursery
Hiawatha Gardens Co.
Old-Fashioned Flower Garden
Chisago Lake Nursery
Laverne Nursery
Norway Poplar Forest Grove

On account of the drought of the summer of 1910 and the dryness during the first part of 1911, some nursery stock was not in particularly good condition. Strawberry plants suffered severely; on the other hand, apple trees did surprisingly well. San Jose Scale was found in two nurseries shipped into Minnesota during the spring of 1911 on currants, fruiting and flowering kind, on plum trees and golden spirea from New York and Pennsylvania. This infested stock was at once destroyed. The Poplar Beetle was quite destructive, but it may be easily controlled. The existence of Putnam's Scale, Oyster Shell Scale and Scurfy Scale on trees adjacent to nursery stock was pointed out to nurserymen and the necessity for cleaning up was emphasized. While these are not to be greatly feared in Minnesota, a shipment of nursery stock bearing any one of them to a western state where laws are stringe

would certainly be destroyed. Grasshoppers, in places, injured apple grafts noticeably. In one nursery spraying was resorted to to kill this pest. Crown Gall, Anthracnose, Rust and Black Rust were in evidence in localities. Two diseases of apple trees hitherto unknown in Minnesota were discovered. One of these was identified by the Division of Plant Pathology—as *Coniothyrium fuckelii.*

On foreign stock in 1911 we found no nest of Brown Tail Moth and no egg clusters of Gipsy Moths, but pupal cases and larval skins of the latter insect were present on imported Azaleas, showing the necessity for keeping up a rigid inspection of all imported stock.

In 1912, fifty-four nurseries were inspected and certificates issued. The list follows:

Hoyt Nursery Co.
Rose Hill Nursery
Vine Grove Nursery
Park Nurseries
Old Fashioned Flower Garden
Deep Haven Nursery
Thos. Redpath Nursery
Minnetonka Nursery
Howard Lake Nursery
Strand's Nursery
Chisago Lake Nursery
Mitchell Nursery
Dodge Co. Nursery
Jewell Nursery Co.
National Nursery Co.
Andrews Nursery Co.
Deerfield Nursery
Brand Nursery Co.
Clinton Falls Nursery Co.
Hutchinson Nursery
Amber Lake Nursery
West Concord Nursery
F. E. Cutting Nursery
Minnesota State Nursery
Farmers Seed & Nursery Co.
Winnebago City Nursery
Southside Nursery
Hawkinson Nursery
Spring Valley Nursery
Johnson Nursery Co.
A. J. Lindert Co.
Turtle Creek Nursery
Fairmont Nursery
Sugar Loaf Valley Nursery
Luverne Nursery
Orton Park Nursery
Albert Lea Nursery
Pioneer Nursery Co.
St. John Nursery Co.
Vinegar Hill Nursery
Sivert's Nursery
Mankato Nursery
Preston Nursery
Fillmore Co. Nursery
Madison Nursery
Tolleson Nursery
Wedge Nursery
Sacred Heart Nursery
Mayfield Nurseries
Northfield Seed Co.
Hiawatha Gardens Nursery
Greenway Fruit Farm
Ritchell Nursery
E. A. Farmer

Mr. C. C. Hunter and Mr. Emil Sahler were inspected in 1912 but have not been granted certificates at date of writing. In 1912 the nurseries were found to be for the most part in good condition. Various injurious insects of minor importance were present to some extent, some crown gall on raspberries, anthracnose, blight and rust, but by no means of universal occurence and not strikingly abundant.

Suggested Changes in Our State Inspection Law.

The newly enacted Federal law, establishing a Quarantine Board which has power to quarantine any part or the whole of a state as far as nursery stock is concerned, should, of itself, show us the need of a more stringent inspection law in Minnesota, since under those conditions Minnesota nurserymen could ship no stock out of the state and intra-state shipments would in all probability be restricted.

Our present law is faulty in many respects, viz.: the entomologist cannot legally inspect ornamental or nursery stock on private grounds where stock it not grown for sale, although there may be the most startling evidence of the presence of dangerous insect pests, imported or domestic, thereon. At present, inspection only takes place once a year and then only upon request of the owner. It is evident that a pest may have established itself in the nursery subsequent to inspection, and the owner, not desiring and not asking for inspection the following year, unconsciously be the means of a very undesirable insect gaining a firm hold.

Our law as now worded directs the inspector to grant a certificate to *anyone* raising nursery stock, if such stock is free of pests. Such a party may be merely an agent, owning only a quarter of an acre, or even renting said ground, which is frequently merely a place where left-overs or unsalable stock is planted. This condition of affairs should be provided for and guarded against.

The entomologist believes that the State, not the nurserymen (as at present) should pay the expense of inspection, for manifest reasons.

Post office authorities and express companies have recently become quite careful in insisting upon a certificate of inspection being attached to every package of stock, stating that it "was grown where inspected." This has given rise in Minnesota at least to some peculiar requests upon the part of one or two parties selling stock. Without mentioning names we will say that A represents a Minnesota dealer who buys stock and has it shipped directly from a grower in some other state to his customer, but A does not wish to advertise the nurseryman (in New York, let us say, or in Pennsylvania) from which he purchases and he also desires his customer to think, if possible, that the order comes from his (A's) establishment. Therefore, A asks the Minnesota inspector to sign his name, officially, to a statement to the effect that the stock shipped "was inspected where grown," said declaration to be attached to each

package shipped by the firm from whom A buys the stock. Manifestly, we have no authority to act outside of this state, and have felt obliged to refuse to do this, such decision being endorsed by the Attorney General.

It is to be noted in this connection that officials in one or two states to our certain knowledge are willing to certify (and have done so) that A owns a nursery (in locality from which purchases are made) etc. This is manifestly a misrepresentation. Some provision, however, should be made in our law for dealers in our own state who buy from inspected nurseries *in Minnesota*, and, not wishing to advertise same, are nevertheless obliged to place a certificate on stock shipped outside the state.

We append here an address by Mr. H. B. Scammel, our deputy inspector in 1911, delivered before the Minnesota State Horticultural Society at its winter meeting in December, 1911. It indicates very plainly upon what points our law is weak and how such weakness may be remedied.

Needed Changes in the Horticultural Inspection Law.

The present law applying to horticultural inspection in Minnesota was enacted by the legislature in 1903 and revised in 1905. It filled a long felt want and served its purpose fairly well during the past eight years, but there are some features embodied in this bill which do not cover the situation existing today, and it is earnestly hoped that some changes and additions may be made, desirable from the standpoint of the inspector as well as from that of the nurseryman, which will became part of the law at the next session of the legislature.

Some states in which fruit growing has become one of the leading industries need, and have adopted, laws sufficiently stringent to afford good protection within their borders; other states, such as our own, the Dakotas and lesser fruit raising states have horticultural laws less severe, and it seems right that differences in the state laws should exist because of the differences in conditions which are found in various parts of this country.

Our own law is of a type quite different from that of California or New York, but our nursery and fruit growing interests are not developed to the same extent as in the former states, and it would seem that with some changes we could secure a law which would better satisfy Minnesota conditions.

The most noticeably weak point in our law is that which limits inspection to places where trees or plants are grown for sale. This may be done at the request of the owner, or when the inspector has reasonable ground to believe that any injurious insect pests or dangerous plant diseases exist, but bear in mind that none other place than that where stock is grown for sale may be inspected. Minnesota nurseries and orchards have been comparatively free of serious insect pests but suppose an orchard is found infested with San Jose scale and the owner refuses to spray. In such case he cannot be reached under the inspection law, but possibly something might be done under some other law, such as maintaining a public nuisance.

It should be required that every nursery be inspected at least once each year, and the right granted to examine any place which the entomologist may have reason to believe needs attention. It cannot be too strongly advocated that a list of the places from which buds and scions are secured by nurserymen be obtained from them and a careful inspection be made of the tree from

which the buds and scions are taken. These are often responsible for the outbreak of an infestation of scale insects, such as San Jose, Oyster Shell, Putnam and Scurfy. The first named is not known to exist in our orchards, but the latter three are quite common, and should trees bearing them be shipped into a state where all stock received is inspected they would undoubtedly be destroyed.

In no section of the law can there be found a statement saying that shipments within the state should have a certificate attached. Shipments destined for other states require it, and it was to meet that requirement that the present law was passed. The idea being to enable nurserymen to do business outside the state, but not being sufficiently particular about the business done at home. Certificates should be on all shipments, whether outside the state or within. To revoke or withhold a certificate at present means only that the nurseryman is prohibited from shipping to other states requiring certificates, and still allows him to do business within his own state. To require only those nurseries which ship to other states to be inspected aims at protection for those states chiefly and not sufficiently protection for our interests at home. Minnesota needs protection for her own sake as well as for the benefit of surrounding states.

This leads to the question of who shall pay for inspection, the nurseryman or the state. The Minnesota law states that a fee of five dollars per day and expenses shall be collected for the inspection of a nursery. When a number of nurseries are on a circuit it is a most difficult matter to determine the sum to be collected from each, especially the apportioning of the expense account, and it is almost impossible to do this in any way except approximately. The important point in connection with the matter of fees is that the inspector does not always feel at liberty to spend as much time as he would like in a nursery because such time is being paid for by the nurseryman, and it is only fair to him to keep expenses as low as possible. There are two nurseries here, perhaps a third, that, were they in a state where San Jose Scale is common, each would require the time of two men for six or seven days to be properly inspected. This scale having been found in two nurseries this year, received in both cases from eastern states, it has become necessary to spend more time in these examinations, and it is recommended that either the work be done at state expense or a small fee without expenses be charged in order to give the inspector every opportunity to spend a sufficient amount of time in the inspection. An examination of the horticultural inspection laws reveals the fact that in approximately one-fourth of the states inspection is made at the expense of the nurserymen, and usually a fee is charged in addition, while in the other three-fourths the states appropriate funds for this purpose.

The time allotted for this paper permits me to speak of one other point which is that the term "nursery stock" should be defined in the law. Such definition must be broad enough to cover the florist's stock which is received here in the fall from Europe, and permit of its inspection. This stock is often classed as greenhouse stock in this country, but being field grown in Europe it should be inspected for Brown Tail Moths nests and Gypsy Moth egg clusters. A word of advice to those who ship greenhouse stock will not be out of place here. This may be shipped into the state or out of it without a certificate and in order to avoid any delay which might arise if an inspector should hold up a shipment for inspection because of a lack of certificate, every greenhouse manager should clearly label each package with the words "Greenhouse Stock."

This gives an opportunity for an unscrupulous man to practice deception, but if the necessity arises a means will be found to detect such an act.

Horticultural inspection laws are still in the formative period, but constantly changing for the better, weaknesses are being found and corrected, and it is only by continually striving for their improvement that laws can be evolved which will effectually control the situation."

While inspection of nurseries is not compulsory under the Minnesota law, as now worded, our nurseries are compelled by the laws

of other states to have their stock inspected before it is shipped to them. Many of the nurserymen who do not ship outside realize that it is a very good thing to have their stock looked over by an expert from the Agricultural College and his stamp of approval placed thereon, also ask for inspection.

This relation between the Experiment Station and the nurseries works to advantage in a double way; it protects the public, and it insures to nurserymen a careful oversight of their stock and information and help if a dangerous foe is found. The nuserymen are as anxious to keep out undesirable insects and destructive diseases as their patrons are, hence inspection by a representative of their own experiment station appears to them a highly desirable thing.

In a few states, a very few, fortunately, the office of nursery inspector is a political one, and therefore, unfortunately, results in a lack of thoroughness in the work, and loss to both nurserymen and the public. A political appointee, not only may be unfit by knowledge for this work, but, and the more the pity, he may not feel free to act with severity where such is necessary. On the other hand, a member of the experiment station force is not fastened by political strings, he is unhampered in his actions, and by the very nature of his training and position, in a way to help the nurserymen and those who buy nursery stock. The nurserymen, in these days of increasing plant pests brought in from Europe, is in a position to spread these destructive foes to horticulture over the entire country unless the business is safe-guarded by proper inspection. Let us hope that in Minnesota this work may never become a matter of politics and that the state's reputation for clean stock, not only at home, but in other states into which Minnesota nursery stock is shipped, be always retained. The moment Montana Wisconsin, Wyoming, North and South Dakota, Iowa, and other states begin to suspect laxity and looseness in Minnesota nursery inspection, which might come with a politically-appointed inspector, they would shun our stock, buy from states where station inspection was the rule, and profits of Minnesota nurserymen would fall off from fifty to one hundred per cent.

Inspection of Foreign Stock.

The country is to be congratulated, florists as well as nurserymen and their patrons, on the final passage of the so-called Plant Quarantine Act (passed Congress August 20, 1912) which went into effect October 1st of the present year. Under this law a Federal Horticultural Board has been established which has the power

when necessity arises to quarantine any state or portion of any state in this country or to prohibit the importation of stock into the United States from any country or countries. The following conditions of entry have to be complied with by an importer of nursery stock.

(1) He must take out a permit therefor in advance. This permit should preferably be taken out by the person who is to receive the goods at final destination. A broker or commission merchant may take out a permit in his own name, if he imports for his own account, or he can act as agent for and take out the permit in the name of the actual purchaser.

(2) He must see that each package on arrival bears the proper certificate of foreign inspection. (See Regulation 6.)

(3) He must see that each package is marked in accordance with Section 3 of the Act. As a matter of convenience, this marking should also contain the additional information called for in Section 4, to avoid the trouble or remarking before the goods can be delivered for interstate shipment. The certificate and marking should preferably be on the goods before they leave the foreign port.

(4) After December 1, 1912, each shipment must be accompanied with the consular declaration called for in Regulation 9. This declaration must accompany the consular invoice and is not to be attached to the individual container.

What the Importer or Broker Must Do Before the Goods Can Be Shipped or Removed from a Port of Entry.

(1) He must immediately (before shipping or removal) advise the Secretary of Agriculture and State Inspectors in accordance with Section 2 and Regulation 8.

(2) He must see that each container is marked in accordance with Section 4; that is in addition to the information in the label of entry, each container must bear the name and address of the consignee at destination, where the stock is to be inspected by the State, territorial or district official. (See Section 2 and Regulation 8.)

Importers are warned that failure to meet the requirements of the law as outlined above subjects them to the penalties fixed in Section 10 of the Act.

Would-be importers should send to the U. S. Department of Agriculture, office of the Secretary, for Circular 41—"Rules and

Regulations for carrying out the "Plant Quarantine Act." The circular also contains the actual wording of the Act.

This new law, originally introduced and known as the Simmons Bill, will strengthen the position of the inspectors in the various states materially from the fact that they have the backing of federal authorities, not only in the inspection of imported stock, but also, in reality, in inspection of domestic stock as well, for, if a serious insect pest or dangerous plant disease once gains a foothold in a state, either through neglect on the part of a nurseryman, or from any other cause, quarantine would undoubtedly and unquestionably follow.

A weak point in the federal law is the fact that it does not require inspection by state authorities. *It does* require that the inspector be notified, and evidently assumes that each state will be sufficiently interested in clean horticulture to take care of this stock after it has arrived. Minnesota is certainly anxious to be kept free of introduced pests, and both nurserymen and florists are only too glad to co-operate with the entomologist to that end. Further, the Minnesota law gives authority to the State Entomologist to inspect stock "where he has reason to suspect the presence of injurious insects, etc.," thus legalizing the compulsory inspection of this stock imported by nurserymen and florists, but the entomologist *cannot legally inspect stock imported* by *private individuals.* The inspector should be given this authority by the state and also be empowered to inspect orchard or ornamental stock as well as nursery stock, *wherever found.*

This work in Minnesota is increasing and placing added work upon the State Entomologist every year. It is evident that the Department should have one practical, well-qualifed man to take care of all inspection, and that funds should be provided sufficient for such an employee and his expenses. It is a striking fact that however good an inspector a man may be technically, if he is not in a position to give nurserymen information regarding spraying outfits and compounds, and best method of controlling pests found in a nursery, he is hardly acceptable. Therefore, such an employee must of necessity be an all around man along these lines.

OUT STATION APIARY.

Last winter was a severe one upon bees and loss in wintering was in some cases as high as 75 per cent. Therefore, although the summer of 1912 has been an excellent one as regards honey flow, the total amount of honey produced in the State this season is below the average. White Clover and Sweet Clover both did well and Bass Wood was in bloom at a time when bees could take care of the nectar. Notwithstanding favorable conditions during the sum-

Fig. 70. "Who's afraid of bees?" Photo taken in our College Apiary by A. A. Aamodt.

mer, it looks on account of the above winter conditions, as though there would be something of a shortage in the honey supply this fall.

Bees in our apiary are going to their winter quarters in good condition.

The Entomologist gives a course in the elements of bee keeping to college students and a certain number of lectures on this subject to senior school students. Of necessity, all college and school instructions has to be given at a time when one cannot work in the

Fig. 72. The bee-tree, shown in Fig. 73, opened. Aamodt.

Fig. 71. A home-made observation hive in our College Apiary. Aamodt.

field with bees, and therefore, we have recommended to the Dean of the College that sufficient funds be appropriated to insure a man being placed in the field during the summer to demonstrate to farmers and others throughout the State the practical points of bee keeping.

One of the accompanying photographs, Fig. No. 71, shows a small observation hive used in our apiary in order to watch the bees while at work. Fig. No. 73 illustrates a felled tree containing a colony of bees which had made their home in the hollow trunk. This was found just outside of Minneapolis near Brooklyn Center. This colony, by the way, was put into a modern bee hive and in addition to the honey necessary to carry it over winter, a surplus of 30 pounds was obtained.

Fig. 73. Smoking bees in felled bee tree. Aamodt.

The published report of the State Bee Inspector indicates a falling off in the amount of foul brood disease, which may be possibly in part due to the comparatively small percentage of bees which came through the winter.

We believe that the industry of bee keeping is as yet in its infancy in this state and that from the abundance of bee pasturage in almost every section it can be made a most remunerative occupation, to say nothing of the advantage to a farmer of having bees upon the place to assist in pollination.

MINNESOTA INSECT LIFE.

This publication, issued during the spring and summer, has been continued, and is evidently meeting with approval. Through it we are enabled to get timely information to those who need it. An endeavor is made to have the information contained therein in popular form. The publication is intended primarily for citizens of Minnesota. A free copy is mailed on the first of April, May, June, July and August to each address on the rapidly growing mailing list. We insert here contents of the numbers published during 1911 and 1912.

Vol. I, No. 4, April, 1911: Spraying; Self-Boiled Lime Sulphur; Spraying Machine Manufacturers; Insecticide and Fungicide Manufacturers; The Plum Curculio; Strawberry Pests; Codling Moth; Bordeaux; Grape Pests; Black Leaf A Good Contact Insecticide; Naked Snails or "Slugs" in Cold Frame, Greenhouse or Garden; "Sow Bugs" or "Wood Lice.;" Grasshoppers; Plant Lice In Spring; Items.

Vol. I. No. 5, May, 1911: Protection of Seed Corn; Summer Work with Grasshoppers; "Red Spider;" Ants in Garden and Household; "Buffalo Bugs," Carpet Beetles, "Buffalo Moths;" Elm Borers; The Oak Twig Pruner; Mosquitoes; Chicken Hawks; Items of Interest.

Vol. I, No. 6, June, 1911: Save the Birds; Ants in Lawn and Garden; The Currant Worm; White Grubs; Poultry Pests; Scale Insects; The State and Federal Insecticide Laws; Grasshoppers; Items of Interest; "The Poor Little Bugs."

Vol. I, No. 7, July, 1911: Wire Worms and Cut Worms in Field Corn; San Jose Scale in Minnesota; Scale Insects Hatching and Spreading Now; Catching Cut Worm Moths; The Fecundity of Plant Lice; The Grasshopper Situation; Remedies for Mosquitoes and Black Flies; Remedies for Jiggers; Pocket Gophers and Moles; Remedies for Woodchucks; The Corn Bill-Bug; Items.

Vol. I, No. 8, August, 1911: Spraying Machinery; Paris Green vs. Arsenate of Lead; Fall Plowing for Grasshoppers; Borers in Birch Trees; Oaks Killed by Borers; A Late Cut-Worm Attacking Cabbage; Another Gohper Remedy; Flies on Stock, Buffalo Gnats, Etc.; Some Remedies for Rats and Mice; Winter Treatment for Scale Insects.

Vol. I, No. 9, April, 1912: A Word to Orchardists; Winter Spraying; Be Prepared for Insect Pests; Spraying Machine Manufacturers; Insecticide and Fungicide Manufacturers; Weevils in Peas and Beans; Clothes Moths and Carpet Beetles (Buffalo Bugs); The "Silver Fish;" More About the Oak Borer; Recent Appointments in Entomological Division; Publications of Entomologists during 1911 and early part of 1912. Items.

Vol. I, No. 10, May, 1912: Spraying Apples and Plums; The Oak Tree Borer; Proof that Spraying Pays; Cut Worms; The White Grub and "June Beetle;" Strawberry Weevil; Winter Injuries by Mice; Pocket Gophers; The English Sparrow; Campaign Against the House Fly; Our Annual Plea for Insect-Eating Birds; Suggestions for Protecting Corn After Being Planted; Some Mosquito Suggestions; Back Numbers of Insect Life; Items of Interest.

Vol. I, No. 11, June, 1912: Notes from the Orchard; Nursery Inspection Under Auspices of Exp. Station; General Treatment for Insects Eating Leaf or Stem: More About Cut Worm; How to Destroy English Sparrows; Currant Worms; Strawberry Grub; Plant Lice on Snowball and Elsewhere; Flies on Stock; Cabbage Maggots on Radishes; "Weevils" in Flour; Items of Interest.

Vol. I, No. 12, July, 1912: Grasshoppers Serious; Larch Saw Fly; Orchard Spraying; The Onion Maggot; Chironomus Sp.; Clover Seed Chalcis; What Our Men are Doing; Remedies for Bed Bugs; Cheese Maggots or "Skippers" Infesting Ham; Lectures to Farmers During July; Chiggers or Jiggers; Items of Interest.

Vol. II, No. 1, August, 1912: The Wheat Stem Maggot; A New Minnesota Pest, (The "Corn Bill-Bug."); More About the Onion Maggot; A New and Useful Fly Trap; Notes for the Orchard; Slugs on Cherry, Plum and Roses; Ants and Aphids; Birds and Insects; Nursery Inspection; A Short Glossary of Entomological Terms.

NAKED SNAILS OR SLUGS.

During the summer of 1912, naked snails or slugs have been extremely troublesome, their unusual numbers being mostly due to the abundance of rain. These so-called slugs never form a snail. In other words, they never assume a shell. Their eggs are small, round or oval, clear, translucent, with a membranous shell, and are about the size of clover seeds.

We have found lime water to be an excellent preventive against this pest, made by slaking a pound of quick lime in a large pail of water, poured, either with or without the lime that settles at the bottom, upon the infested plants. It might be used possibly a little weaker. The strength required can be easily ascertained by experiment. A touch of this liquid will cause these naked snails to curl up and die, and plants coated with it seem so distasteful to them that they are repelled. This lime water will in no way injure vegetables for table use, and it can be easily washed off from lettuce when necessary, with clear water.

Lime dusted about the plants attacked is extremely helpful in keeping them away. They may also be trapped with slices of potato or turnip, and pieces of board may be placed in the garden under which they conceal themselves toward morning. Turtles, it is claimed, will eat them, and toads also destroy them.

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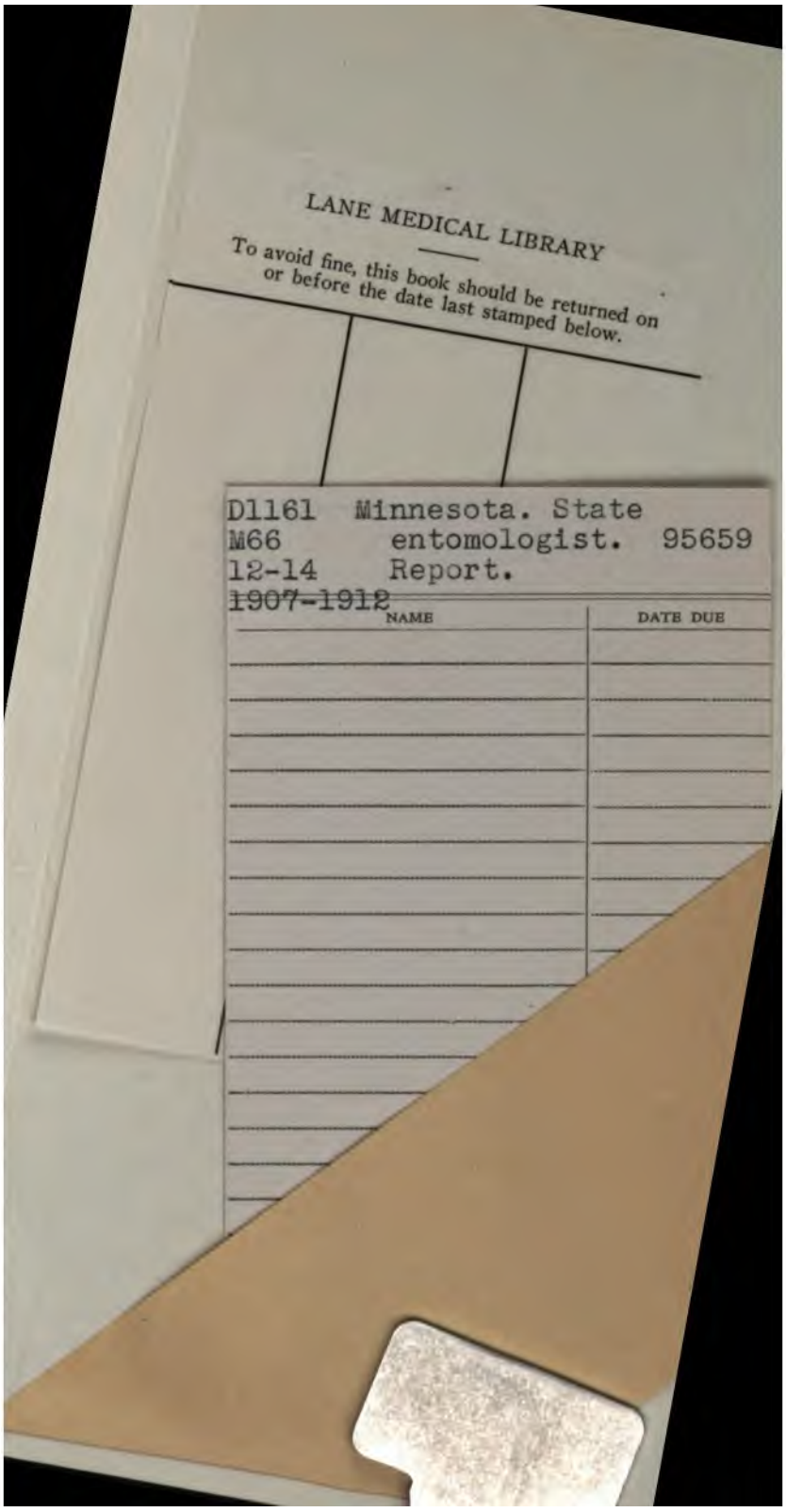
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